



**Office of Water Quality**  
**Total Maximum Daily Load Program**

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**Total Maximum Daily Load for**  
***E. coli* Impairment**  
**Big Blue River Watershed,**  
**Henry and Rush Counties**

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**Indiana Department of Environmental Management  
Total Maximum Daily Load Program  
July 7, 2006**

**Total Maximum Daily Load (TMDL) for *Escherichia coli* (*E. coli*) in the  
Big Blue River Watershed, Henry and Rush Counties, Indiana**

## **Introduction**

In accordance with section 303(d) of the Federal Clean Water Act and the United States Environmental Protection Agency's (USEPA's) Water Quality Planning and Management Regulations (Title 40 of the Code of Federal Regulations (CFR), Part 130) it is required that States develop a Total Maximum Daily Loads (TMDLs) for waterbodies that are not meeting Water Quality Standards (WQS). TMDLs provide States a basis for determining the pollutant reductions necessary from both point and nonpoint sources to restore and maintain the quality of their water resources. The purpose of this TMDL is to identify the sources of the impairment and determine the allowable levels of *E. coli* bacteria for the Big Blue River watershed in Henry and Rush Counties, Indiana. These activities will result in the attainment of the applicable WQS in the Big Blue River watershed.

## **Background**

In 1998, 2000, and 2002, Indiana's Section 303(d) List cited the Big Blue River as being impaired for *E. coli* in Henry and Rush Counties. In addition to the Big Blue River, Indiana's 2002 Section 303(d) List cites four tributaries as being impaired for *E. coli*. All of the above listed segments will be included on the 2006 Section 303(d) List of impaired waters.

The Big Blue River Watershed is listed on the 2004 303(d) List of Impaired Waterbodies for *E. coli*. Based on the data collected in 2002 by IDEM, a reassessment of water quality condition was warranted. This reassessment was completed in January 2006, for the Big Blue River watershed. The reassessment for the *E. coli* impairment resulted in the addition of the following segments in the Big Blue River watershed to the 2006 303(d) List: INW041B\_00, INW0419\_01, INW0417\_00, and INW0413\_00. All other impaired segments were unaffected by this reassessment. (Figure 1, Table 1).

This TMDL will address approximately 53.87 miles of the Big Blue River watershed in Henry and Rush Counties, Indiana, where designated uses are impaired by elevated levels of *E. coli* during the recreational season. All of the thirteen (13) segments of the listed streams for this TMDL are located in the Driftwood River Basin, Hydrologic Unit Code 05120204. This TMDL addresses only the Big Blue River from its headwaters to its confluence with Six Mile Creek approximately six miles downstream of the Town of Carthage (Figure 1). Segments of the remaining portion of the Big Blue River below Six Mile Creek are impaired, but they will not be addressed in this TMDL.

Table 1: 2004 303(d) Listings for Big Blue River Watershed

Waterbody Name	Segment ID Number	Length (Miles)	Impairment
Big Blue River	INW0411_T1001; INW0412_T1002; INW0414_T1003; INW0415_T1004; INW0418_T1005; INW041B_T1006; INW041C_T1007; INW041D_T1008; INW041E_T1009	34.50	<i>E. coli</i>
Montgomery Creek	INW041B_00	4.61	<i>E. coli</i>
Buck Creek	INW0419_01	1.66	<i>E. coli</i>
Duck Creek	INW0417_00	6.75	<i>E. coli</i>
Little Blue River	INW0413_00	6.35	<i>E. coli</i>

Historical data collected by IDEM’s Assessment Branch documented elevated levels of *E. coli* in the Big Blue River watershed from 1991 to 2004. IDEM’s Assessment Branch completed a survey of the watershed for the Big Blue River in 2002. In this survey, IDEM sampled twenty-one (21) sites (Figure 2), five times, with the samples evenly spaced over a 30-day period from June 3, 2002, to July 17, 2002. Each of the twenty-one sites violated the single sample maximum standard and geometric mean standard with the exception of site WED010-0006 (Summit Lake Eastside Boat Ramp). These data were the basis for listing the Big Blue River watershed on the 2004 303(d) List.

The TMDL development schedule corresponds with IDEM’s basin-rotation water quality monitoring schedule. To take advantage of all available resources for TMDL development, impaired waters are scheduled according to the basin-rotation schedule unless there is a significant reason to deviate from this schedule. Waterbodies could be scheduled based on the following:

- 1) Waterbodies may be given a high or low priority for TMDL development depending on the specific designated uses that are not being met, or in relation to the magnitude of the impairment.
- 2) TMDL development of waterbodies where other interested parties, such as local watershed groups, are working on alleviating the water quality problem may be delayed to give these other actions time to have a positive impact on the waterbody. If water quality standards still are not met, then the TMDL process will be initiated.
- 3) TMDLs that are required due to water quality violations relating to pollutant parameters where no EPA guidance is available may be delayed to give EPA time to develop guidance.

This TMDL was scheduled based on the data available from the basin-rotation schedule, which represents the most accurate and current information available on water quality within waterbodies covered by this TMDL.

## Numeric Targets

The impaired designated use for the waterbodies in the Big Blue River watershed is for total body contact recreational use during the recreational season, April 1<sup>st</sup> through October 31<sup>st</sup>.

Indiana Administrative Code 327 IAC 2-1-6(d), establishes the full body contact recreational use *E. coli* WQS<sup>1</sup> for all waters in the state of Indiana as follows:

*E. coli* bacteria, using membrane filter (MF) count, shall not exceed one hundred twenty-five (125) per one hundred (100) milliliters as a geometric mean based on not less than five (5) samples equally spaced over a thirty (30) day period nor exceed two hundred thirty-five (235) per one hundred (100) milliliters in any one (1) sample in a thirty (30) day period.

The sanitary wastewater *E. coli* effluent limits from point sources during the recreational season, April 1<sup>st</sup> through October 31<sup>st</sup>, are also covered under 327 IAC 2-1-6(d).

For the Big Blue River watershed during the recreational season (April 1<sup>st</sup> through October 31<sup>st</sup>), the target level is set at the *E. coli* WQS of 125 per one hundred milliliters as a 30-day geometric mean based on not less than five samples equally spaced over a thirty day period.

## Source Assessment

### Watershed Characterization

The Big Blue River in Henry and Rush Counties is located in a predominantly agricultural watershed. The Big Blue River flows from northern Henry County into Summit Lake. From Summit Lake, the Big Blue River flows southwest through Henry County and into northwestern Rush County until entering eastern Shelby County. The Big Blue River flows through the City of New Castle in Henry County and the Town of Carthage before it is joined by the Six Mile Creek and enters another HUC that is not the focus of this TMDL. Four tributaries that feed the Big Blue River are impaired for *E. coli*. These tributaries include Montgomery Creek, Buck Creek, Duck Creek, and the Little Blue River (Figure 1).

### *E. coli* Data

Thirteen of the twenty-one sampling sites for the Big Blue River watershed are located on the Big Blue River (Attachment A; Figure 2). For legibility in Figure 2, site numbers have been reduced to the last two digits of the full site name. All sites addressed in this TMDL begin with the nomenclature “WED010-00xx, where “xx” is the site number in Figure 2. Two of the twenty-one sampling sites were sampled at the Carthage and New Castle Waste Water Treatment Plants (WWTPs). The four tributaries, Buck Creek (WED010-0009), Duck Creek (WED010-0010), Little Blue River (WED010-0013) and Montgomery Creek (WED010-0019 and WED010-0021) were sampled at the nearest upstream bridge location above the confluence of the Big Blue River. Montgomery Creek was sampled at the two closest bridge locations upstream of the Big Blue. One of the twenty-one sampling sites was taken at the east boat ramp on Summit Lake (WED010-0006). Combining the *E. coli* data at these sampling sites, these twenty-one sites violated the single sample maximum standard approximately 76.9% of the time. The highest single sample maximum standard was recorded at >2419.1 cfu/100mL at Sites WED010-0019 and WED010-0022. The geometric mean was exceeded 95.2% of the time. The highest geometric mean recorded was 1842 cfu/100mL at Site WED010-0022.

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<sup>1</sup> *E. coli* WQS = 125 cfu/100ml or 235 cfu/100ml; 1 cfu (colony forming units)= 1 mpn (most probable number)

## **Tributaries**

Each of the tributaries described above (Buck Creek, Duck Creek, Montgomery Creek, and Little Blue River) has a sample point located close to the Big Blue River, sufficiently upstream to avoid influence from the Big Blue River. These sites were chosen to represent the amount of *E. coli* load in the Big Blue River from that particular sub-watershed. Each of these sub-watersheds is impaired for *E. coli*. Along with these sub-watersheds, many tributaries along the Big Blue River in Henry and Rush Counties may also be impaired for *E. coli*. Based on the *E. coli* data collected on the Big Blue River and its tributaries, it can be concluded that these tributaries are contributing to the *E. coli* impairment in Big Blue River (Figure 2).

## **Landuse**

Landuse information was assembled using data collected from the 1992 Gap Analysis Program (GAP). In 1992, approximately 66% of the landuse along the Big Blue River was row crop agriculture. The remaining landuse along the Big Blue River consisted of approximately 19% grass/pasture, 9% palustrine wetlands, 4% urban, and 2% water (Figure 3). A comparison of landuse information from 1992 with aerial photos taken in 2003 shows there is little substantial change to the area along the Big Blue River.

## **Wildlife**

Wildlife is a known source of *E. coli* impairments in waterbodies. Many animals spend time in or around waterbodies. Deer, geese, ducks, raccoons, turkeys, and other animals all create potential sources of *E. coli*. Wildlife contributes to the potential impact of contaminated runoff from animal habitats, such as urban park areas, forest, and cropland.

## **Septic Systems**

Many homes within the Big Blue watershed treat wastewater with on-site septic systems. Failing septic systems are known sources of *E. coli* impairment in waterbodies. Conversations with the Henry and Rush County Health Department staff indicate that septic system failure does occur, but no tangible septic failure rate has been established by either local Health Department at this time (Henry County Health Department and Rush County Health Department, 2006).

## **National Pollutant Discharge Elimination System (NPDES) Permitted Dischargers**

Thirteen permitted NPDES facilities discharge into the Big Blue River or its tributaries (Figure 4, Appendix 1). Three of the thirteen facilities have no sanitary component to their discharge or have a pretreatment permit. These three facilities are Jefferson-Smurfit Corps (US) (IN0001350), Allegheny Ludlum Steel (IN0045284), and Speedway 5229 (ING080205). Seven of the remaining ten permitted facilities have *E. coli* limits due to having a sanitary component. These are Blue River Valley Jr/Sr High School (IN0031399), Days Inn WWTP (IN0045063), Knightstown Municipal WWTP (IN0040177), Gasamerica Services, Inc. (IN0043966), Carthage Municipal STP (IN0024937), New Castle Municipal STP (IN0023914), and Golden Pebble Estates MHP (IN000041181). One site, Kennard Municipal STP (IN0040151) is currently under an enforcement action and will have *E. coli* limits in its next permit when the enforcement action is resolved. Two of the thirteen permitted facilities have Total Residual Chlorine Limits. These are Summit Lake State Park (IN0048011) and Knightstown Crossing WWTP (IN0059617).

Previously, facilities with design flows less than 1 MGD (million gallons per day) (typically minor municipals and semipublics) were not required to have *E. coli* effluent limits or conduct monitoring for *E. coli* bacteria, provided they maintained specific Total Residual Chlorine (TRC) levels in the chlorine contact tank. The assumption was that as long as chlorine levels were adequate in the chlorine contact tank, the *E. coli* bacteria would be deactivated and compliance with the *E. coli* WQS would be met by default. The original basis for allowing chlorine contact tank requirements to replace bacteria limits was based on fecal coliform, not *E. coli*. No direct correlation between the Total Residual Chlorine levels and *E. coli* bacteria can be conclusively drawn. Further, it has been shown that exceedances of *E. coli* bacteria limits may still occur when the chlorine contact tank requirements are met.

The following facilities have recorded some violations of their *E. coli* limits in the previous five years. However, according to the IDEM's inspectors for each site, these upsets were primarily due to heavy rain events and subsequent flooding in and around the Big Blue River. Since, these sites are not consistently violating their limits, except during extreme weather conditions, these facilities are not considered significant sources of *E. coli* to the Big Blue River.

IN0031399	Blue River Valley Jr/Sr HS	Tributary to Big Blue
IN0045063	Days Inn WWTP	Big Blue River
IN0040177	Knightstown Municipal WWTP	Big Blue River
IN0043966	Gasamerica Services, Inc	Montgomery Creek
IN0024937	Carthage Municipal STP	Big Blue River
IN0023914	New Castle Municipal STP	Big Blue River
IN0041181	Golden Pebble Estates MHP	Duck Creek

Three of ten NPDES facilities have Total Residual Chlorine limits, but will have *E. coli* limits added to their permits upon renewal. These facilities are Summit Lake State Park (IN0048011), Knightstown Crossing WWTP (IN0059617), and Kennard Municipal STP (IN0040151). The Kennard Municipal STP permit expired in 2002 and the facility continued to operate without a permit. They may have contributed to the *E. coli* impairment during this time. However, the facility has reapplied for a permit and is currently working with IDEM staff to achieve compliance and necessary upgrades to their system to allow for proper functioning of their plant. The Summit Lake State Park and Knightstown Crossing have had plant upsets, mostly during high rainfall events and flood conditions and are not considered a significant source of *E. coli* to the Big Blue River.

The remaining three NPDES permitted facilities to the Big Blue River do not have a sanitary component to their discharge or are a pretreatment permit. These facilities include Jefferson-Smurfit Corps (US) (IN0001350), Allegheny Ludlum Steel (IN0045284), and Speedway #5229 (ING080205). Since these three facilities do not contain a sanitary component to their discharge, or do not discharge to a stream, they are not considered a source of *E. coli* to the Big Blue River.

### **Combined Sewer Overflows (CSO) & Sanitary Sewer Overflows (SSO)**

There is one CSO community along the Big Blue River (Figure 5, Appendix 2). The City of New Castle has eight CSOs. CSO outfalls 007, 008, 009, 010 discharge into the Big Blue River, 003 and 006 discharge into Castle Run, 004 discharges into Mound Run, and 005 discharges into Baker Branch. These waterbodies are all tributaries to the Big Blue River. The City of New Castle also has one SSO (011) and it discharges into the Big Blue River. The City of New Castle has submitted their CSO Long Term Control Plan to IDEM in December 2004.

The Town of Carthage is not a CSO community but has three SSOs. SSOs 001 and 002 discharge into Carthage Creek, which is a tributary to the Big Blue River, and SSO 004 discharges into the Big Blue

River along the east split. The Town of Carthage is not a CSO Community and is not required to submit a CSO Long Term Control Plan.

SSOs are not a permitted activity and are considered an illegal discharge. CSO and SSO outfalls are considered a significant source of *E. coli* to the Big Blue River watershed.

### **Storm Water General Permit Rule 13**

The City of New Castle is the only Municipal Separate Storm Sewer System (MS4) community within the Big Blue River Watershed. Guidelines for MS4 permits and timelines are outlined in Indiana's Municipal Separate Storm Sewer System (MS4) Rule 13 (327 IAC 15-13-10 and 327 IAC 15-13-11). It can be determined that the MS4 community is a potential source of *E. coli* to the Big Blue River. However, prior to the completion of the permit requirements, it is difficult to determine the magnitude of *E. coli* impact this MS4 community has on the Big Blue River.

### **Confined Feeding Operations and Concentrated Animal Feeding Operations**

The removal and disposal of manure, litter, or processed wastewater that is generated as the result of Confined Feeding Operations falls under the regulations for Confined Feeding Operations (CFOs) and Concentrated Animal Feeding Operations (CAFOs). There are five CFOs near the Big Blue River, none of which are considered CAFOs (Figure 6, Appendix 3). These facilities are Sullivan Farms (4566), Cox (2642), Houchins Farms (4971), Weimer (1272) and Masters (2812). There are three inactive CFOs, Elliot, Weber, and Hernly, which no longer have number of animal information. The CFO and CAFO regulations (327 IAC 16, 327 IAC 15) require operations "not cause or contribute to an impairment of surface waters of the state." The active animal operations near the Big Blue River have no open enforcement actions at this time. However, these operations are still considered a potential source of *E. coli* for the Big Blue River.

### **Small Animal Operations**

There are many smaller livestock operations in the watershed. These operations, due to their small size, are not regulated under the CFO or CAFO regulations. These operations may still have an impact on the water quality and the *E. coli* impairment. No specific information on these small livestock operations is currently available for the remaining portion of the Big Blue River. However, it is believed that these small livestock operations may be a source of the *E. coli* impairment.

### **Linkage Analysis**

The linkage between the *E. coli* concentrations in the Big Blue River watershed and the potential sources of *E. coli* provides the basis for the development of this TMDL. Analysis of this relationship allows for estimating the total assimilative capacity of the stream and any needed load reductions. Water quality duration curves were created for the sampling sites in the Big Blue River watershed that were sampled by IDEM in 2002. A flow duration interval is described as a percentage. Zero (0) percent corresponds to the highest stream discharge (flood condition) and 100 percent corresponds to the lowest discharge (drought condition). These sampling sites are representative of the hydrodynamics of the Big Blue River watershed (Attachment B). This section will discuss the water quality durations and the linkage of Section 3.0 for the Big Blue River and its primary tributaries.

## Water Quality Duration Curves

Six water quality duration curves were created for the sampling sites in the Big Blue River watershed (Attachment B). The first curve has been generated for the mainstem Big Blue River that includes all data points including all data points on tributaries. This was done to capture as many different flow levels as possible to show an overall picture of the watershed. The second curve is a single sampling location at the base of the watershed. The remaining four curves are from single sampling locations on each of the four primary tributaries; Montgomery Creek, Buck Creek, Duck Creek, and Little Blue River.

Site WED010-0035 is the point furthest downstream on the Big Blue River below the town of Carthage. All data points are portrayed on this curve. An overall reduction of 68% in the geometric mean would be needed in order to achieve water quality standards for the Big Blue River Watershed. The water quality duration curve for this site shows higher *E. coli* values during moist and mid-range flows. This overall reduction of the geometric mean shows the consistency within the entire watershed of contributions throughout the watershed. Data from Summit Lake is not included in the analysis due to the unique nature of lakes as natural sinks of *E. coli*. The travel time of water from the time it enters the lake to the time it leaves the lake allows for natural die off of the *E. coli* bacteria.

Site WED010-0034 is located on the Big Blue River just below the town of Carthage and directly above the Carthage WWTP. It is also located below the CSOs of the town. The geometric mean value at this site is 431 cfu/100mL. A 71% reduction would be needed in order to achieve water quality standards for main stem. The water quality duration curve for this site shows higher *E. coli* values during mid to moist flow conditions.

Site WED010-0019 is located on Montgomery Creek above the confluence with the Big Blue River. The geometric mean value at this site is 432 cfu/100mL. A 71% reduction would be needed in order to achieve water quality standards for this tributary. The water quality duration curve for this site shows higher *E. coli* values during mid to moist flow conditions.

Site WED010-0009 is located on Buck Creek above the confluence with the Big Blue River. The geometric mean value at this site is 307 cfu/100mL. A 59% reduction would be needed in order to achieve water quality standards for this tributary. The water quality duration curve for this site shows higher *E. coli* values during mid to moist flow conditions.

Site WED010-0010 is located on Duck Creek above the confluence with the Big Blue River. The geometric mean value at this site is 841cfu/100mL. An 85% reduction would be needed in order to achieve water quality standards for this tributary. The water quality duration curve for this site shows higher *E. coli* values during mid to moist flow conditions.

Site WED010-0013 is located on the Little Blue River above the confluence with the Big Blue River. The geometric mean value at this site is 325 cfu/100mL. A 62% reduction would be needed in order to achieve water quality standards for this tributary. The water quality duration curve for this site shows higher *E. coli* values during mid to moist flow conditions.

Montgomery Creek and Duck Creek have higher levels of needed reduction than the Little Blue River and Buck Creek. Both Montgomery and Duck Creeks have larger drainage areas and have local wastewater treatment plants and confined feeding operations within the drainage are. Little Blue River requires less of a reduction even though it does have similar drainage area; there are no wastewater treatment plants or confined feeding operations in the area. Buck Creek, which has the lowest reduction needed, has only a small drainage area. The sample was taken at the mouth of the creek, but below a small lake. The overall reductions on individual creeks within the watershed, as compared to the single sample point at the

furthest downstream point on the Big Blue River, addressed in this TMDL show similarities especially in the mid- to moist flow ranges. These similarities show the consistent nature of *E. coli* impairment throughout the watershed.

### Source Linkage

The landuse in this watershed is predominately agricultural. Row crops comprise 66% of the landuse. The soils in this sub-watershed necessitate the use of field tiles to drain excess water from the fields. These field tiles then drain to the nearest stream. Field tiles are not themselves sources of *E. coli*, but they can carry *E. coli* from land applied manure, runoff from the fields and pastures, and other sources of *E. coli* not adjacent to the streams. The high *E. coli* values during mid-range to moist flow conditions indicates the presence of *E. coli* transportation by field tiles and overland flow.

Pasture comprises 19% of the landuse. This indicates the presence of non-regulated smaller animal operations in this sub-watershed. Animals are not as likely to enter a stream during high flow conditions. Since there is a continuous source of *E. coli* present in this watershed during mid-range conditions, this would indicate that animals have direct access to the stream.

Forests only comprise 4% of the landuse. The forested areas are located along the stream banks, which creates a buffer strip. Buffer strips assist in slowing the time of transport of the contaminant, in this case *E. coli*, to the stream. Due to the choice of sampling locations, this is only slightly reflected in the results.

Wildlife is a known source of *E. coli*. The predominant agricultural landuses in this watershed create ideal habitats for wildlife. Wildlife would contribute during all flow conditions with possible spikes during high flow conditions due to runoff or flooding that cannot be absorbed by natural forests or man-made buffer strips.

Three of the thirteen NPDES permitted facilities in this sub-watershed do not contain a sanitary component in their discharge; therefore, these facilities are not considered sources of *E. coli*. The remaining ten facilities only have upsets recorded during higher flow and flood condition, and can contribute to the impairment during these times, but otherwise are within their limits the majority of times.

Permitted CFOs are clustered in the south and southwest section of the watershed primarily in the Montgomery Creek watershed. CFOs could be sources of *E. coli* during high flow conditions on the water quality duration curve. These facilities have the potential to cause a violation of the *E. coli* water quality standard through land application or a malfunction at the facility. However, all of these facilities are operating in compliance with their permit. There are no CAFOs in operation within this watershed.

Septic systems are a known source of *E. coli* for this sub-watershed based on information provided to IDEM by the Henry and Rush County Health Department (Henry and Rush County Health Department personnel communication). The septic systems described by this information would provide a constant source of *E. coli* particularly during low to mid-range flow conditions. According to the water quality duration curve, there are consistent violations of the *E. coli* water quality standard during these flow conditions. Septic systems can also fail during higher flow conditions by leaching to a field tile or other type of pipe that discharges to the stream. Violations of the *E. coli* water quality standard are shown on the water quality duration curves during high flow, but not consistently.

There are three SSOs from the town of Carthage watershed. Site WED010-0034 is located downstream of these SSOs. There are seven CSOs and one SSO in the City of New Castle. Sites WED010-0027, WED010-0026, and WED010-0028 are located downstream of these CSOs and SSO. CSOs and SSOs

are typically shown on water quality duration curves during high and moist flow events. However, there were no high flow events recorded during the sampling events. Sites WED010-0027 and WED010-0028 show higher *E. coli* values during moist flows, but do fall within the range of other values within the watershed. Site WED010-0034, located just downstream of the Carthage STP and SSOs only has a reduction of 37%. This could be caused by the STP effluent being well below discharge limits as well as SSOs that are not utilized as much during moist conditions as those in the City of New Castle. It can be concluded that CSOs and SSOs are a source of *E. coli* in this watershed.

Municipal Separate Storm Sewer System (MS4) permits are being issued in the state of Indiana. The City of New Castle is the only Municipal Separate Storm Sewer System (MS4) community within the Big Blue River Watershed. They have submitted their CSO Long Term Control Plan to IDEM in December 2004. Once this permit has been issued and implemented, water quality should improve in the Big Blue River Watershed. Guidelines for MS4 permits and timelines are outlined in Indiana's Municipal Separate Storm Sewer System (MS4) Rule 13 (327 IAC 15-13-10 and 327 IAC 15-13-11). This permit will be used to address storm water impacts in the Big Blue River Watershed.

## Conclusions

The *E. coli* data have an average single sample maximum violation 66% of the time and an average geometric mean violation 95% of the time. There are NPDES permitted facilities with sanitary components in this watershed. There are no CFO violations and the CFOs are considered to be in compliance. No CAFO facilities are in operation within this watershed. The City of New Castle, an MS4 community, is considered a source of *E. coli*. Based on the water quality duration curves, it can be concluded that the majority of sources of *E. coli* in this watershed are nonpoint sources which include small animal operations, wildlife, leaking and failing septic systems. CSOs and SSOs can also contribute during high flows when there is excessive water in the watershed to cause overflows.

## TMDL Development

The TMDL represents the maximum loading that can be assimilated by the waterbody while still achieving the Waters Quality Standard (WQS). As indicated in the Numeric Targets section of this document, the target for this *E. coli* TMDL is 125 per one hundred milliliters as a geometric mean based on not less than five samples equally spaced over a thirty-day period from April 1 through October 31. Concurrent with the selection of a numeric concentration endpoint, TMDL development also defines the critical conditions that will be used when defining allowable levels. Many TMDLs are designed as the set of environmental conditions that, when addressed by appropriate controls, will ensure attainment of WQS for the pollutant. For example, the critical conditions for the control of point sources in Indiana are given in 327 IAC 5-2-11.1(b). In general, the 7-day average low flow in 10 years (Q7, 10) for a stream is used as the design condition for point source dischargers. However, *E. coli* sources to Big Blue River Watershed arise from a mixture of dry and wet weather-driven conditions, and there is no single critical condition that would achieve the *E. coli* WQS. For the Big Blue River Watershed and the contributing sources, there are a number of different allowable loads that will ensure compliance, as long as they are distributed properly throughout the watershed.

For most pollutants, TMDLs are expressed on a mass loading basis (e.g. pounds per day). For *E. coli* indicators, however, mass is not an appropriate measure because *E. coli* is expressed in terms of organism counts (or resulting concentration) (USEPA, 2001). Meeting the Water Quality Standards (WQS) of 125 colony forming unit (cfu) per 100 mL as a geometric mean and 235 cfu/100 mL is the overall goal of the TMDL. The geometric mean *E. coli* WQS allows for the best characterization of the watershed. The geometric mean provides a more reliable measure of *E. coli* concentration because it is less subject to random variation (USEPA, 2004). However, by setting the target to meet the 125 cfu/100 mL geometric

mean standard, this TMDL also will meet the 235 cfu/100 mL single day standard. Therefore, this *E. coli* TMDL is concentration-based consistent with 327 IAC 5-2-11.1(b) and 40 CFR, Section 130.2 (i) and the TMDL is equal to the geometric mean *E. coli* WQS for each month of the recreational season (April 1 through October 31).

The Wasteload Allocation and Load Allocations in the TMDL are set at 125 cfu/mL, which, as stated above, also will meet the 235 cfu/100 mL single day standard.

## Allocations

TMDLs are comprised of the sum of individual wasteload allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels. In addition, the TMDL must include a Margin of Safety (MOS), either implicitly or explicitly that accounts for uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is denoted by the equation:

$$\text{TMDL} = \sum \text{WLAs} + \sum \text{LAs} + \text{MOS}$$

The term TMDL represents the maximum loading that can be assimilated by the receiving water while still achieving WQS. The overall loading capacity is subsequently allocated into the TMDL components of WLAs for point sources, LAs for nonpoint sources, and the MOS. This *E. coli* TMDL is concentration-based consistent with USEPA regulations at 40 CFR, Section 130.2(i).

To investigate further the potential sources mentioned above, an *E. coli* load duration curve analysis, as outlined in an unpublished paper by Cleland (2002), was developed for each of the major tributaries in the watershed. The load duration curve analysis is a relatively new method utilized in TMDL development. The method considers how stream flow conditions relate to a variety of pollutant loadings and their sources (point and non-point).

In order to develop a load duration curve, continuous flow data is required. The USGS gage for the Big Blue River at Carthage (03361000) was used to generate the load duration curves for the Big Blue River.

The flow data are used to create flow duration curves, which display the cumulative frequency of distribution of the daily flow for the period of record. The flow duration curve relates flow values measured at the monitoring station to the percent of time that those values are met or exceeded. Flows are ranked from extremely low flows, which are exceeded nearly 100% of the time, to extremely high flows, which are rarely exceeded. Flow duration curves are then transformed into load duration curves by multiplying the flow values along the curve by applicable water quality criteria values for *E. coli* and appropriate conversion factors. The load duration curves are conceptually similar to the flow duration curves in that the x-axis represents the flow recurrence interval and the y-axis represents the allowable load of the water quality parameter. The curve representing the allowable load of *E. coli* was calculated using the single sample maximum and geometric mean standards of 235 *E. coli* per 100 ml and 125 *E. coli* per 100 ml, respectively. The final step in the development of a load duration curve is to add the water quality pollutant data to the curves. Pollutant loads are estimated from the data as the product of the pollutant concentrations, instantaneous flows measured at the time of sample collection, and appropriate conversion factors. In order to identify the plotting position of each calculated load, the recurrence interval of each instantaneous flow measurement was defined. Water quality pollutant monitoring data are plotted on the same graph as the load duration curve that provides a graphical display of the water quality conditions in the waterbody (Attachment C). The pollutant monitoring data points that are above the target line exceed the water quality standards (WQS); those that fall below the target line meet the WQS (Mississippi DEQ, 2002).

## Wasteload Allocations

There are thirteen permitted dischargers in the Big Blue River Watershed. Ten of the thirteen permitted dischargers have a sanitary component to their discharge. Seven of the thirteen permitted dischargers already have *E. coli* limits in their permits. Three of those ten permitted dischargers have total residual chlorine limits (Summit Lake State Park (IN0048011), Knightstown Crossing WWTP (IN0059617), and Kennard Municipal STP (IN0040151)). in their permits and will receive *E. coli* limits in their next permit cycle. Three of the thirteen do not have a sanitary component in their discharge or are a pretreatment permit that is connected to another WWTP for additional treatment.

The Waste Load Allocation (WLA) for all permitted facilities with a sanitary component is set at the WQS of 125 per one hundred milliliters as a geometric mean based on not less than five samples equally spaced over a thirty-day period from April 1<sup>st</sup> through October 31<sup>st</sup>. Any facility that has a sanitary component to their permit with Total Residual Chlorine will be changed to the *E. coli* WQS when their permit is renewed.

The WLA for prohibited discharges from SSOs and septic systems with straight pipe discharges directly to streams is set at zero (0.0).

## Load Allocations

The Load Allocation (LA) for nonpoint sources is equal to the WQS of 125 per one hundred milliliters as a geometric mean based on not less than five samples equally spaced over a thirty-day period from April 1<sup>st</sup> through October 31<sup>st</sup>. The LA will use the geometric mean of each sampling location to determine the reduction necessary to comply with WQS at each site (Appendix 4). The geometric means have additionally been broken down into a flow regime that will help identify critical flows and areas for the implementation of this TMDL (Appendix 4).

Load allocations may be affected by subsequent work in the watershed. There are currently no watershed projects or plans in the Big Blue River Watershed. However, there have been several watershed projects completed in the surrounding areas. IDEM plans to work with the watershed coordinators in the surrounding areas along with local government agencies to encourage interest in watershed projects. It is anticipated that watershed projects will be useful in continuing to define and address the nonpoint sources of the *E. coli* in the Big Blue River Watershed.

## Margin of Safety

A Margin of Safety (MOS) was incorporated into this TMDL analysis. The MOS accounts for any uncertainty or lack of knowledge concerning the relationship between pollutant loading and water quality. The MOS can be either implicit (e.g., incorporated into TMDL analysis through conservative assumptions) or explicit (e.g., expressed in the TMDL as a portion of the loadings). This TMDL uses an implicit MOS by applying two conservative assumptions. First, no rate of decay for *E. coli* was applied. *E. coli* bacteria have a limited capability of surviving outside of their hosts. Therefore, a rate of decay is normally applied. However, applying a rate of decay could result in a discharge limit that would be greater than the *E. coli* WQS, thus no rate of decay was applied. Second, IDEM determined that applying the *E. coli* WQS of 125 per one hundred milliliters to all flow conditions and with no rate of decay for *E. coli* is a more conservative approach that provides for greater protection of the water quality. Therefore, the *E. coli* WQS was applied to all flow conditions thus creating a more conservative MOS for this TMDL.

## Seasonality

Seasonality in the TMDL is addressed by expressing the TMDL in terms of the *E. coli* WQS for total body contact during the recreational season (April 1<sup>st</sup> through October 31<sup>st</sup>) as defined by 327 IAC 2-1-6(d). There is no applicable total body contact *E. coli* WQS during the remainder of the year in Indiana. *E. coli* WQS will be met regardless of flow conditions in the applicable season, because this is a concentration-based TMDL.

## Monitoring

Future *E. coli* monitoring of the Big Blue River Watershed will take place during IDEM's five-year rotating basin schedule and/or once TMDL implementation methods are in place. Monitoring will be adjusted as needed to assist in continued source identification and elimination. IDEM will monitor at an appropriate frequency to determine if Indiana's 30-day geometric mean value of 125 *E. coli* per one hundred milliliters is being met. When these results indicate that the waterbody is meeting the *E. coli* WQS, the waterbody will then be removed from the 303(d) list.

## Reasonable Assurance Activities

Reasonable assurance activities are programs that are in place or will be in place to assist in meeting the Big Blue River Watershed TMDL allocations and the *E. coli* Water Quality Standard (WQS). Following is a list of reasonable assurance activities that pertain to the Big Blue River Watershed.

### National Pollutant Discharge Elimination System (NPDES) Permitted Dischargers

For the permitted dischargers that have only total residual chlorine limits (Summit Lake State Park (IN0048011), Knightstown Crossing WWTP (IN0059617), and Kennard Municipal STP (IN0040151)), in their current permits, during the next permitting cycle, IDEM will assure that these facilities are complying with Water Quality Standards.

The City of New Castle is the one Combined Sewer Overflow (CSO) community discharger to the Big Blue River Watershed. The City of New Castle is currently in the Long Term Control Plan (LTCP) permitting process. This process will address any concern about CSO discharges causing or contributing to the violation of the *E. coli* WQS.

The City of New Castle and the Town of Carthage are Sanitary Sewer Overflow (SSO) communities that discharge to the Big Blue River Watershed. This activity is prohibited. Continual monitoring and work with these facilities is needed to eliminate these types of discharges. This will assure that they no longer cause or contribute to violations of the *E. coli* WQS.

### Storm Water General Permit Rule 13

Municipal Separate Storm Sewer System (MS4) permits are being issued in the state of Indiana. The one MS4 community in the Big Blue River Watershed is the City of New Castle. Once this permit has been issued and implemented, they will improve the water quality in the Big Blue River Watershed.

Guidelines for MS4 permits and timelines are outlined in Indiana's Municipal Separate Storm Sewer System (MS4) Rule 13 (327 IAC 15-13-10 and 327 IAC 15-13-11). This permit will be used to address storm water impacts in the Big Blue River Watershed.

### **Confined Feeding Operations (CFOs) and Confined Animal Feeding Operations (CAFOs)**

CFOs and CAFOs are required to manage manure, litter, and process wastewater pollutants in a manner that does not cause or contribute to the impairment of *E. coli* WQS. IDEM inspects these facilities on a regular basis for compliance.

### **Watershed Projects**

There are currently no active 319 grant projects within the Big Blue Watershed boundaries as discussed within this document.

IDEM has recently hired a Watershed Specialist for this area of the state. The Watershed Specialist will be available to assist stakeholders with starting a watershed group, facilitating planning activities, and serving as a liaison between watershed planning and TMDL activities in the Big Blue River Watershed.

### **Potential Future Activities**

Nonpoint source pollution, which is the primary cause of *E. coli* impairment in this watershed, can be reduced by the implementation of "Best Management Practices" (BMPs). BMPs are practices used in agriculture, forestry, urban land development, and industry to reduce the potential for damage to natural resources from human activities. A BMP may be structural, that is, something that is built or involves changes in landforms or equipment, or it may be managerial, that is, a specific way of using or handling infrastructure or resources. BMPs should be selected based on the goals of a watershed management plan. Livestock owners, farmers, and urban planners, can implement BMPs outside of a watershed management plan, but the success of BMPs would be enhanced if coordinated as part of a watershed management plan. Following are examples of BMPs that may be used to reduce *E. coli* runoff:

### **Watershed Groups**

Henry and Rush County along with the Friends of the Big Blue River have shown an interest in forming a group to address the impairments in the Big Blue River Watershed.

### **Riparian Area Management**

Management of riparian areas protects stream banks and riverbanks with a buffer zone of vegetation, either grasses, legumes, or trees. If the buffer strip is established on the contour, runoff flows evenly across the entire surface of the grass strip, reducing sheet and rill erosion.

### **Manure Collection and Storage**

Collecting, storing, and handling manure in such a way that nutrients or bacteria do not run off into surface waters or leach down into groundwater.

### **Contour Row Crops**

Farming with row patterns and field operations aligned at or nearly perpendicular to the slope of the land. Farming on the contour creates small ridges that slow runoff water. In contour row cropping, the small grain or hay strips slow runoff water, allowing infiltration and filtering sediment.

### **Manure Nutrient Testing**

If manure application is desired, sampling and chemical analysis of manure should be performed to determine nutrient content for establishing the proper manure application rate in order to avoid over application and runoff.

### **Drift Fences**

Drift fences (short fences or barriers) can be installed to direct livestock movement. A drift fence parallel to a stream keeps animals out and prevents direct input of *E. coli* to the stream.

### **Pet Clean-up / Education**

Education programs for pet owners can improve water quality of runoff from urban areas.

### **Septic Management/Public Education**

Programs for management of septic systems can provide a systematic approach to reducing septic system pollution. Education on proper maintenance of septic systems as well as the need to remove illicit discharges could alleviate some anthropogenic sources of *E. coli*.

### **Conclusion**

The sources of *E. coli* to the Big Blue River include both point and nonpoint sources. In order for the Big Blue River Watershed to achieve Indiana's *E. coli* WQS, the wasteload and load allocations for the Big Blue River Watershed in Indiana have been set to the *E. coli* WQS of 125 per one hundred milliliters as a geometric mean based on not less than five samples equally spaced over a thirty day period from April 1<sup>st</sup> through October 31<sup>st</sup>. Achieving the wasteload and load allocations for the Big Blue River Watershed depends on:

- 1) *E. coli* limits being added to dischargers who monitor for total residual chlorine.
- 2) Assure compliance with any CFO or future CAFO permits so that they do not cause or contribute to violations of the *E. coli* WQS.
- 3) Nonpoint sources of *E. coli* being controlled by implementing best management practices in the watershed.
- 4) The issuance of the MS4 permits for the City of New Castle.
- 5) The issuance of a LTCP for the City of New Castle.

The next phase of this TMDL is to identify and support the implementation of activities that will bring the Big Blue River Watershed in compliance with the *E. coli* WQS. IDEM will continue to work with its existing programs on implementation. In the event that designated uses and associated water quality criteria applicable to the Big Blue River Watershed are revised in accordance with applicable requirements of state and federal law, the TMDL implementation activities may be revised to be consistent with such revisions. Additionally, IDEM will work with local stakeholder groups to pursue best management practices that will result in improvement of the water quality in the Big Blue River Watershed.

## References

Cleland, B. 2002 TMDL Development from the “Bottom Up”-Part II. Using Duration Curves to Connect the Pieces. America’s Clean Water Foundation.

ESRI. June 2004. <[http://www.esri.com/data/download/census2000\\_tigerline](http://www.esri.com/data/download/census2000_tigerline)>.

Indiana Department of Environmental Management (IDEM), 1998. Indiana 1998 303(d) List of Impaired Waterbodies for Total Maximum Daily Load (TMDL) Development.

Mississippi Department of Environmental Quality. 2002. Fecal Coliform TMDL for the Big Sunflower River, Yazoo River Basin.

USEPA. 2001. Protocol for Developing Pathogen TMDLs. United States Environmental Protection Agency, 841-R-00-002.

USEPA. 2004. Water Quality Standards for Coastal and Great Lakes Recreation Waters. United States Environmental Protection Agency. 04-25303. Pg 67224.

## Appendix 1: NPDES Permits in the Big Blue River Watershed

### Facilities with *E. coli* Limits

Permit No.	Facility Name	Receiving Waters
IN0031399	Blue River Valley Jr/Sr HS	Tributary to Big Blue
IN0045063	Days Inn WWTP	Big Blue River
IN0040177	Knightstown Municipal WWTP	Big Blue River
IN0043966	Gasamerica Services, Inc	Montgomery Creek
IN0024937	Carthage Municipal STP	Big Blue River
IN0023914	New Castle Municipal STP (Permit Admin extended, 2 <sup>nd</sup> Public Notice 10-28-2005)	Big Blue River
IN0041181	Golden Pebble Estates MHP (Permit issued 4-26-2005 will have <i>E. coli</i> limits)	Duck Creek

### Facilities with Total Residual Chlorine Limits

Permit No.	Facility Name	Receiving Waters
IN0048011	Summit Lake State Park	Big Blue River
IN0059617	Knightstown Crossing WWTP	Montgomery Creek

### Expired Facilities under enforcement

Permit No.	Facility Name	Receiving Waters
IN0040151	Kennard Municipal STP Facility is under enforcement, lagoon no longer meets state requirements	Montgomery Creek

### Facilities with no Sanitary Component

Permit No.	Facility Name	Receiving Waters
IN0001350	Jefferson-Smurfit Corps (US)	Big Blue River
IN0045284	Allegheny Ludlum Steel	Big Blue River
ING080205	Speedway 5229	Big Blue River

**Appendix 2: Combined Sewer Overflows and Sanitary Sewer Overflows in Big Blue River Watershed**

**City of New Castle**

CSO

<u>Outfall #</u>	<u>Location (Latitude/Longitude)</u>	<u>Receiving Waters</u>
003C	RR Tracks just N of New York Ave(39.9377/-85.3739)	Castle Run
004C	Bundy Ave (39.9189/-85.3768)	Mound Run
005C	8 <sup>th</sup> St (39.9067/-85.3766)	Baker Branch
006C	RR Tracks just N of New York Ave(39.93708/-85.7386)	Castle Run
007C	Just N of SR38, S of RR (39.93336/-85.37386)	Big Blue River
008C	Just N of CR 100 S (39.91758/-85.39531)	Big Blue River
009C	Just N or CR 100 S (39.95183/-85.50497)	Big Blue River
010C	Just S of SR38 (39.93017/-8538428)	Big Blue River

SSO

<u>Outfall #</u>	<u>Location (Latitude/Longitude)</u>	<u>Receiving Waters</u>
011Z	Old Spiceland Rd (39.90839/-85.38647)	Elliott Run

**Town of Carthage**

SSO

<u>Outfall #</u>	<u>Location (Latitude/Longitude)</u>	<u>Receiving Waters</u>
001Z	Harrison (39.73703/-85.56619)	Carthage Ck
002Z	Henry & Main St (39.73653/-85.57267)	Carthage Ck
004Z	Main St N of Town (39.74458/-85.56981)	Big Blue River (East Split)

**Appendix 3: CFOs in the Big Blue River Watershed**

<b>Log #</b>	<b>Name</b>	<b>Approved Animals</b>		
		<b>Nursery Pigs</b>	<b>Growers/ Finishers</b>	<b>Sows/ Boars</b>
4566	Sullivan Farms	1200	620	56
2642	Cox	1150	650	316
4971	Houchins Farms	1920	1000	704
1272	Weimer	2400	1400	300
2812	Masters	235	437	0

**Appendix 4: Big Blue River Watershed Reductions**

***E. Coli* (cfu/100mL) Duration Curve Zone Geometric Means and Reductions**

Site ID	Big Blue River Watershed								Site Name and Segment ID
	High 0-10	Moist 10-40	Mid-Range 40-60	Dry 60-90	Low 90-100	Site Geometric Mean	Overall Site Reductions	Area	
WED010-0003		325, 686, 410, 980	325			494	75%	178.5	Big Blue River at 5th St Carthage (900N) INW04E_1009
WED010-0004		920, 770, 866, 648	866			808	85%	71.5	Big Blue River at Henry CR 350 W, N of Spiceland INW0415_T1004
WED010-0006		13, 2	3, 2, 5			4	Meets WQS	NA	Summit Lake Boat ramp East Side INW0419_P1051
WED010-0009		344, 365, 344, 325	191			307	59%	19.1	Buck Creek at S Mill Rd INW0419_00
WED010-0010		726, 547, 726, 1119	1299			841	85%	26.2	Duck Creek at Greensboro Rd INW0417_00
WED010-0013		365, 228, 162, 613	435			325	62%	10.0	Big Blue River at SR 103 INW0413_00
WED010-0019		547, 209, 157, 2419.1	344			432	71%	23.6	Montgomery Creek at Knightstown INW0F1B_00
WED010-0020		193, 727	488, 435, 488			429	71%	10.0	Little Blue River at SR 103 at Wilbur Wright FWA INW0413_00
WED010-0021		105, 547	272, 298, 238			257	51%	23.0	Montgomery Creek at US40 Knightstown City limits, City Park INW041B_00
WED010-0022		2419.1, 1299, 1413, 2401	1986			1842	93%	1.9	Big Blue River at CR 600 N INW0411_T1001
WED010-0023		37, 63, 166, 461	261			137	9%	11.4	Big Blue River at Muncie Pike INW0412_T1002
WED010-0024		116, 160, 166, 344	344			206	39%	14.1	Big Blue River at SR 36 INW0412_T1002
WED010-0025		142, 210, 248, 1046	435			320	61%	25.3	Big Blue River at CR 300 N INW0412_T1002

***E. Coli* (cfu/100mL) Duration Curve Zone Geometric Means and Reductions**

Site ID	Big Blue River Watershed								Site Name and Segment ID
	High 0-10	Moist 10-40	Mid-Range 40-60	Dry 60-90	Low 90-100	Site Geometric Mean	Overall Site Reductions	Area	
WED010-0026		2401, 16, 613, 488	920			403	69%	NA	New Castle WWTP at Midway Dr INW0414_T1003
WED010-0027		325, 275, 648, 1413	517			532	76%	49.5	Big Blue River at CR 100 S INW0414_T1003
WED010-0028		1732, 435, 920, 1203	770			916	86%	54.2	Big Blue River at CR 125 W INW0414_T1003
WED010-0030		435, 686, 686, 579	816			627	80%	102.7	Big Blue River at Mill Rd INW0418_T1005
WED010-0032		325, 648, 613, 816	726			598	79%	130.6	Big Blue River at US 40 INW041B_T1006
WED010-0033		2401, 648, 84	12			200	37%	NA	Carthage STP at CR 800 N INW041E_T1009
WED010-0034		166, 488, 461, 1203	328			431	71%	191.8	Big Blue River at CR 800 N INW041E_T1009
WED010-0035		193, 488, 365, 1203	224			393	68%	197.6	Big Blue River at CR 800 E INW041E_T1009

# Big Blue River Watershed

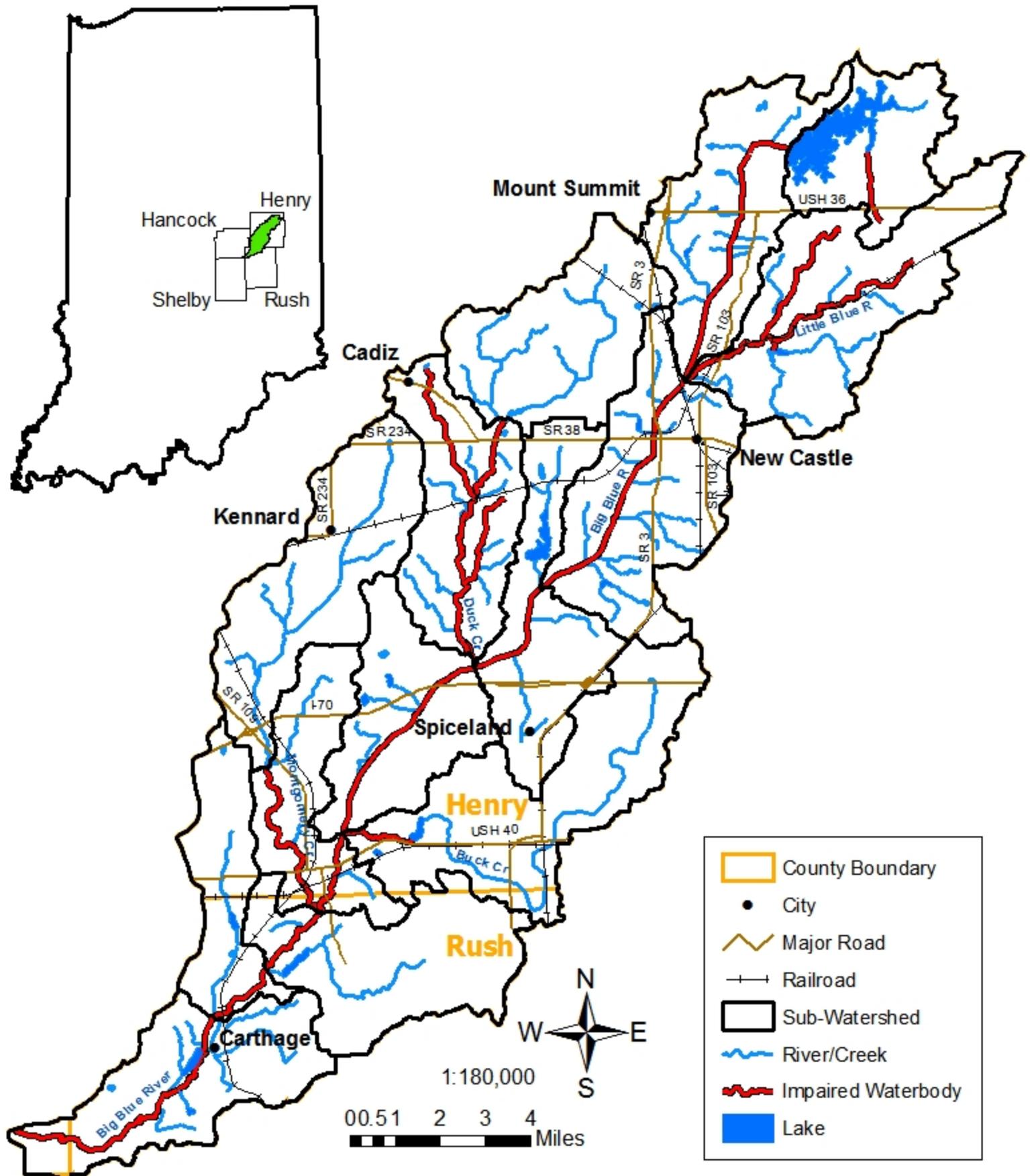


Figure 1: Big Blue River Watershed Location with Impaired Waterbodies

# Big Blue River Watershed

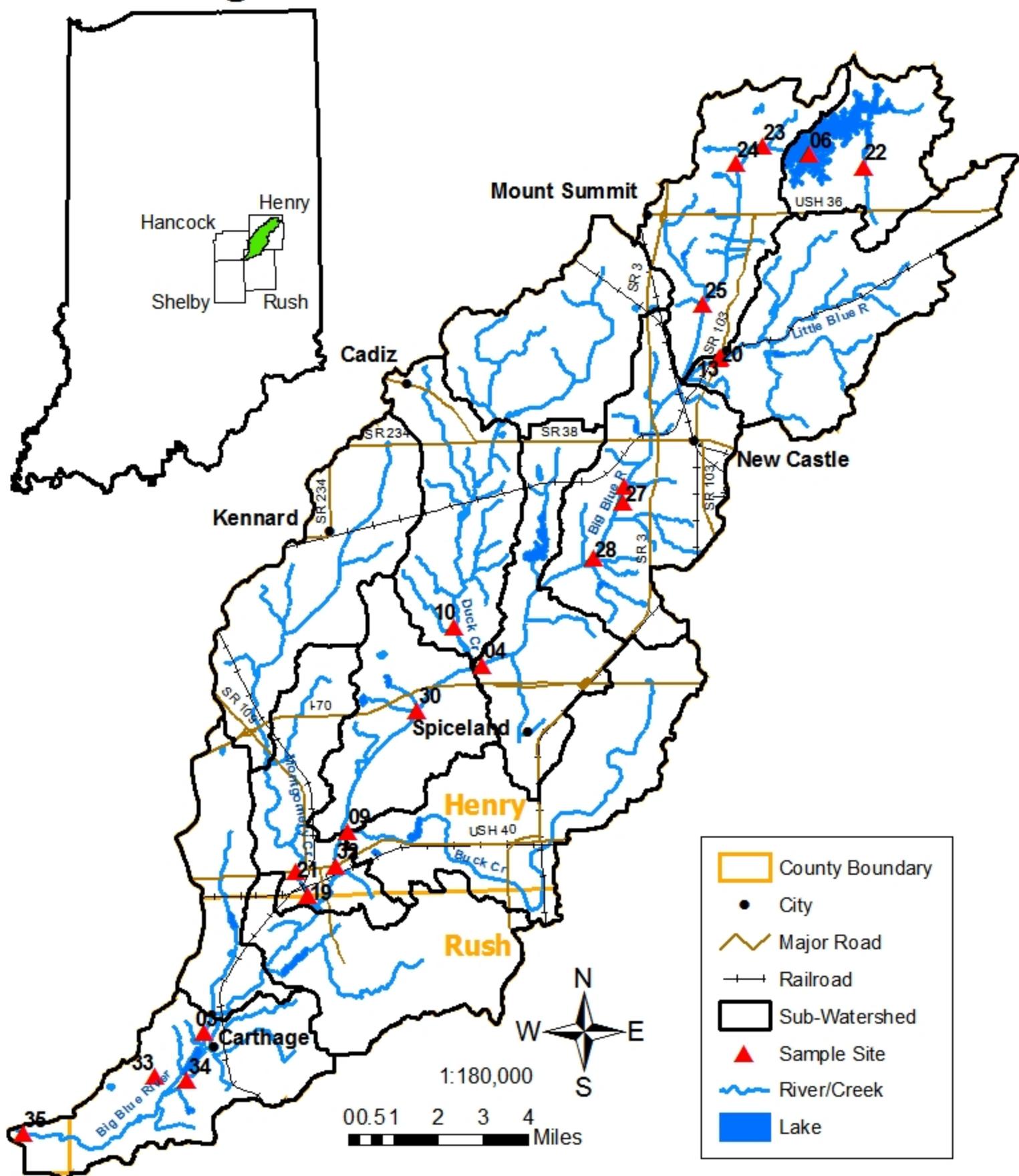


Figure 2: Sampling sites in the Big Blue River Watershed

# Big Blue River Watershed

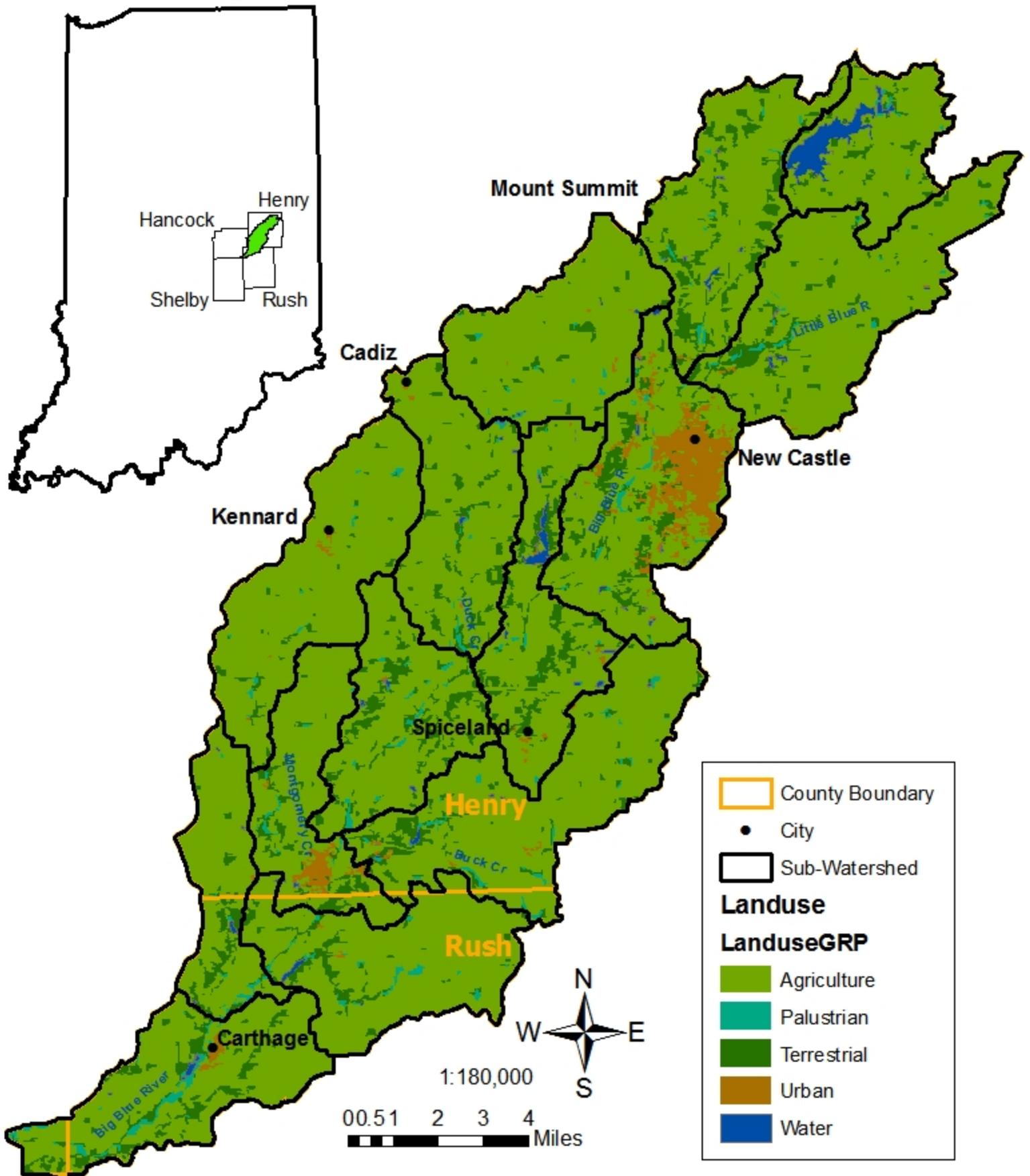


Figure 3: Landuse in the Big Blue River Watershed

# Big Blue River Watershed

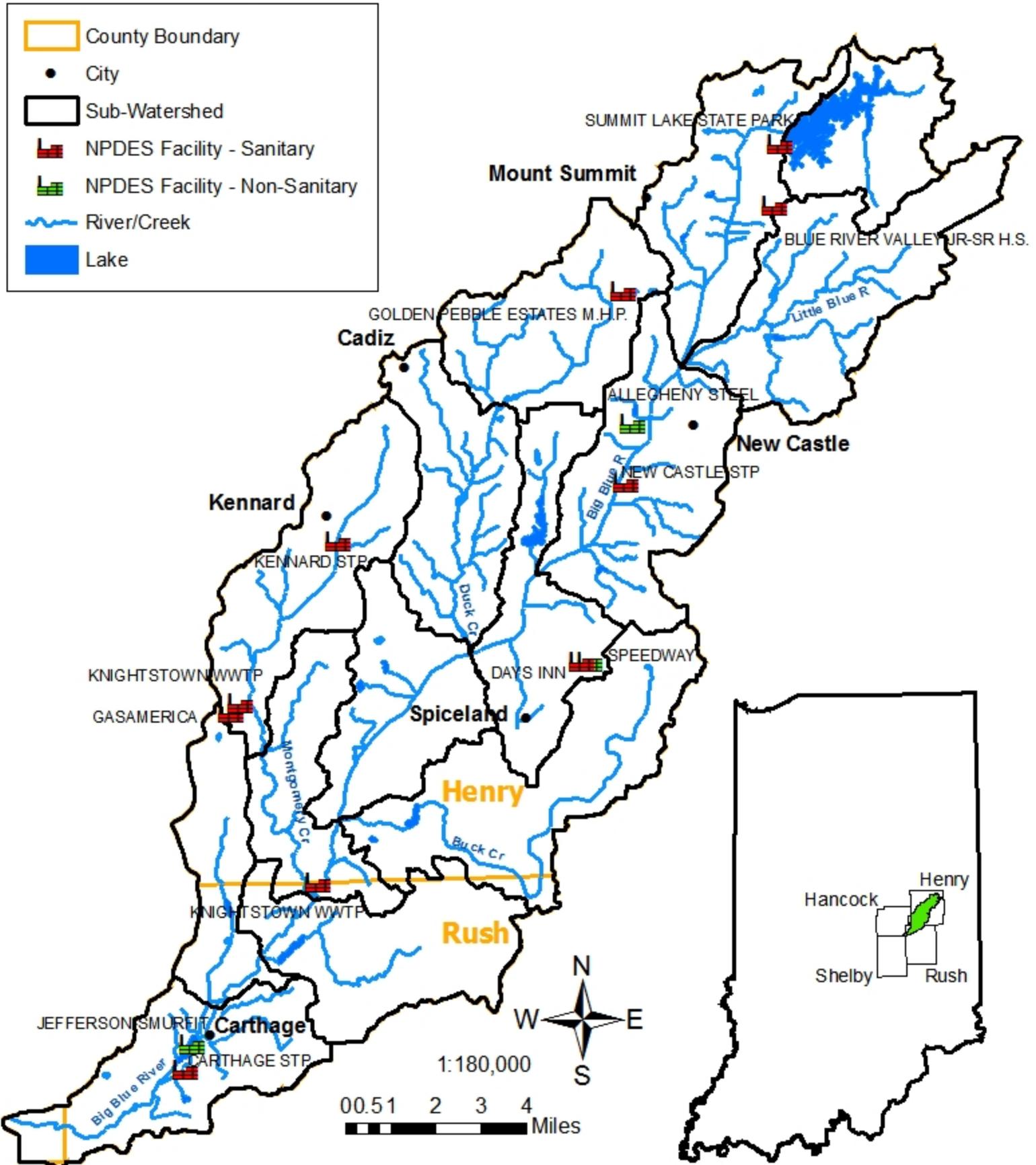


Figure 4: NPDES Facilities in the Big Blue River Watershed

# Big Blue River Watershed

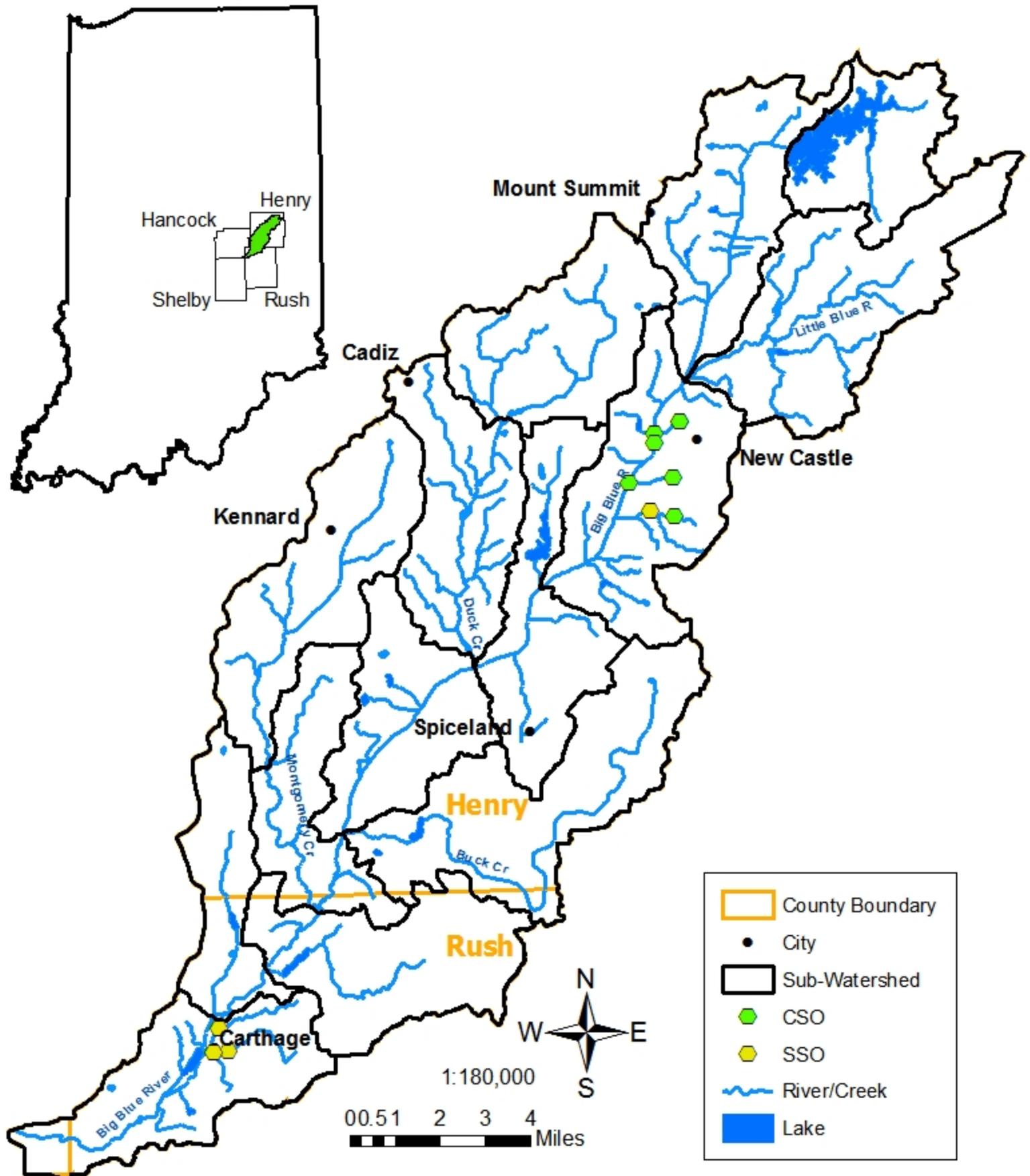


Figure 5: Combined Sewer Overflow and Sanitary Sewer Overflow in the Big Blue River Watershed

# Big Blue River Watershed

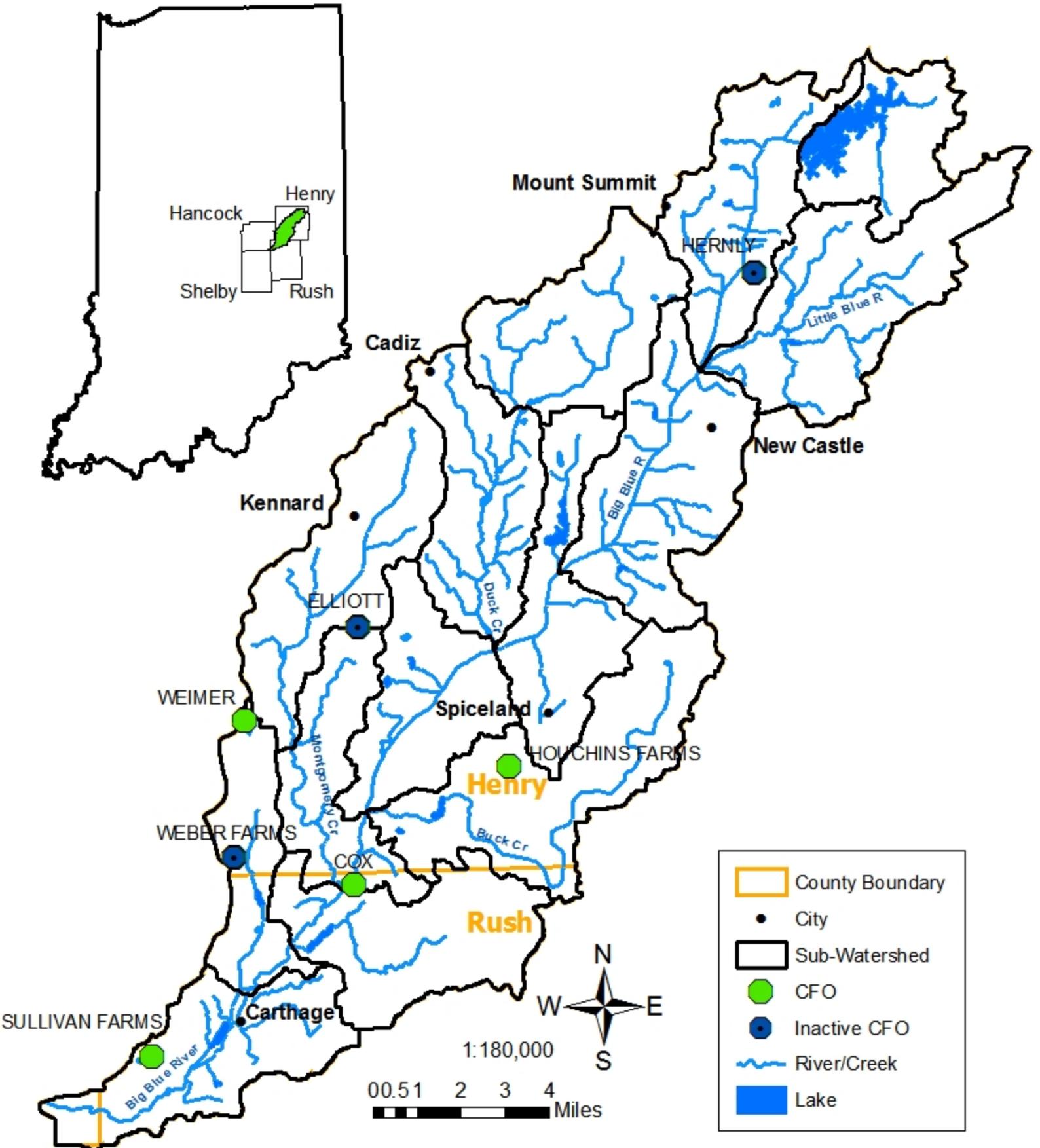


Figure 6: Confined Feeding Operations in the Big Blue River Watershed

## **Attachment A**

### ***E. coli* Data for the Big Blue River Watershed TMDL**

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## Attachment A

Project Name	Stream	Site Location	Site #	UTM Northing	UTM Easting	Sample Number	Geometric Mean	Parameter
2002 Big Blue R/Rays Crossing Assessment	Big Blue River	At 5th St Carthage (900N)	WED010-0003	4400209.2	622023.2	AA12162	494	MPN/100mL
2002 Big Blue R/Rays Crossing Assessment	Big Blue River	At Henry CR 350 W, N of Spiceland	WED010-0004	4413389.3	632009.5	AA12157	808	MPN/100mL
2002 Big Blue R/Rays Crossing Assessment	Big Blue River	CR 600 N	WED010-0022	4431245.3	645653.3	AA12148	1842	MPN/100mL
2002 Big Blue R/Rays Crossing Assessment	Big Blue River	Muncie Pike	WED010-0023	4431997.2	642036.0	AA12149	137	MPN/100mL
2002 Big Blue R/Rays Crossing Assessment	Big Blue River	SR 36	WED010-0024	4431368.2	641099.9	AA12146	206	MPN/100mL
2002 Big Blue R/Rays Crossing Assessment	Big Blue River	CR 300 N	WED010-0025	4426313.0	639914.5	AA12151	320	MPN/100mL
2002 Big Blue R/Rays Crossing Assessment	Big Blue River	C.R. 100 S	WED010-0027	4419790.5	637087.9	AA12154	532	MPN/100mL
2002 Big Blue R/Rays Crossing Assessment	Big Blue River	CR 125 W	WED010-0028	4417233.5	635976.2	AA12155	916	MPN/100mL
2002 Big Blue R/Rays Crossing Assessment	Big Blue River	Mill Rd	WED010-0030	4411764.8	629680.0	AA12158	627	MPN/100mL
2002 Big Blue R/Rays Crossing Assessment	Big Blue River	US 40	WED010-0032	4406195.8	626743.8	AA12160	598	MPN/100mL
2002 Big Blue R/Rays Crossing Assessment	Big Blue River	CR 800 N	WED010-0034	4398504.2	621443.1	AA12164	431	MPN/100mL
2002 Big Blue R/Rays Crossing Assessment	Big Blue River	CR 800 E	WED010-0035	4396591.8	615558.4	AA12165	393	MPN/100mL
2002 Big Blue R/Rays Crossing Assessment	Buck Cr	S Mill Rd	WED010-0009	4407416.7	627165.0	AA12159	307	MPN/100mL
2002 Big Blue R/Rays Crossing Assessment	Carthage STP	CR 800 N	WED010-0033	4398639.5	620262.2	AA12163	200	MPN/100mL
2002 Big Blue R/Rays Crossing Assessment	Duck Cr	Greensboro Rd	WED010-0010	4414759.9	631011.5	AA12156	841	MPN/100mL
2002 Big Blue R/Rays Crossing Assessment	Little Blue River	SR 103	WED010-0013	4424396.9	640482.3	AA12152	325	MPN/100mL
2002 Big Blue R/Rays Crossing Assessment	Montgomery Cr	Knightstown	WED010-0019	4405142.4	625775.2	AA12161	432	MPN/100mL
2002 Big Blue R/Rays Crossing Assessment	New Castle WWTP	Midway Dr	WED010-0026	4419239.5	637048.2	AA12153	403	MPN/100mL
2002 E. coli in Whitewater River	Little Blue River	SR 103 at Wilbur Wright FWA	WED010-0020	4424406.6	640502.3	AA12314	429	MPN/100mL
2002 E. coli in Whitewater River	Montgomery Cr	US 40 at Knightstown City limits, City Park	WED010-0021	4405972.2	625315.8	AA12312	257	MPN/100mL
2002 E. coli in Whitewater River	Summit Lake	Boat ramp East Side	WED010-0006	4431705.6	643714.6	AA12315	4	MPN/100mL

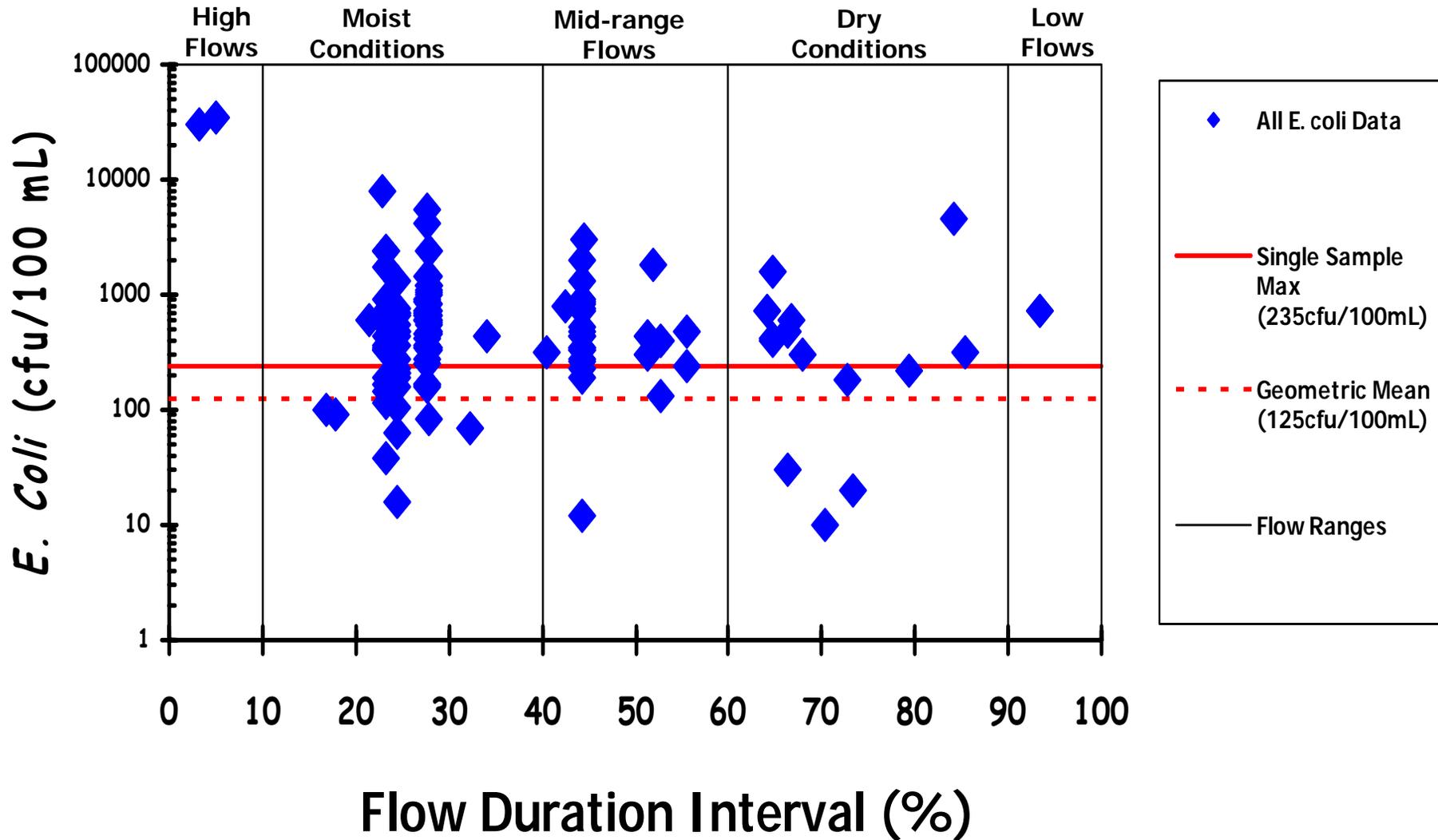
**Attachment B**

**Water Quality Duration Curves for the Big Blue River Watershed  
TMDL**

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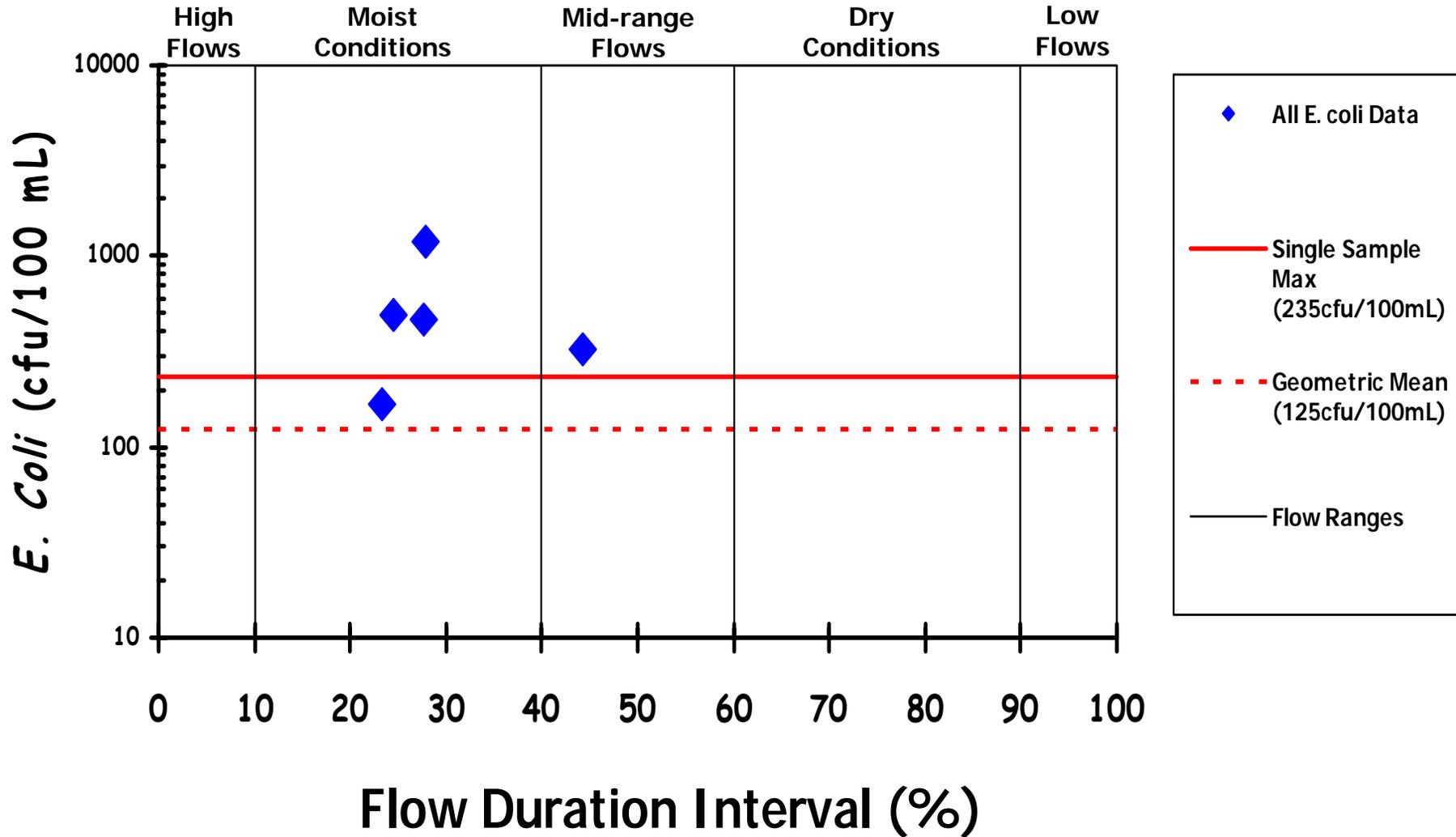
# Big Blue River at CR 800 E near Carthage, IN

## *E. coli* Water Quality Duration Curve - Site: WED010-0035



# Big Blue River at CR 800 N near Carthage, IN

## *E. coli* Water Quality Duration Curve - Site: WED010-0034



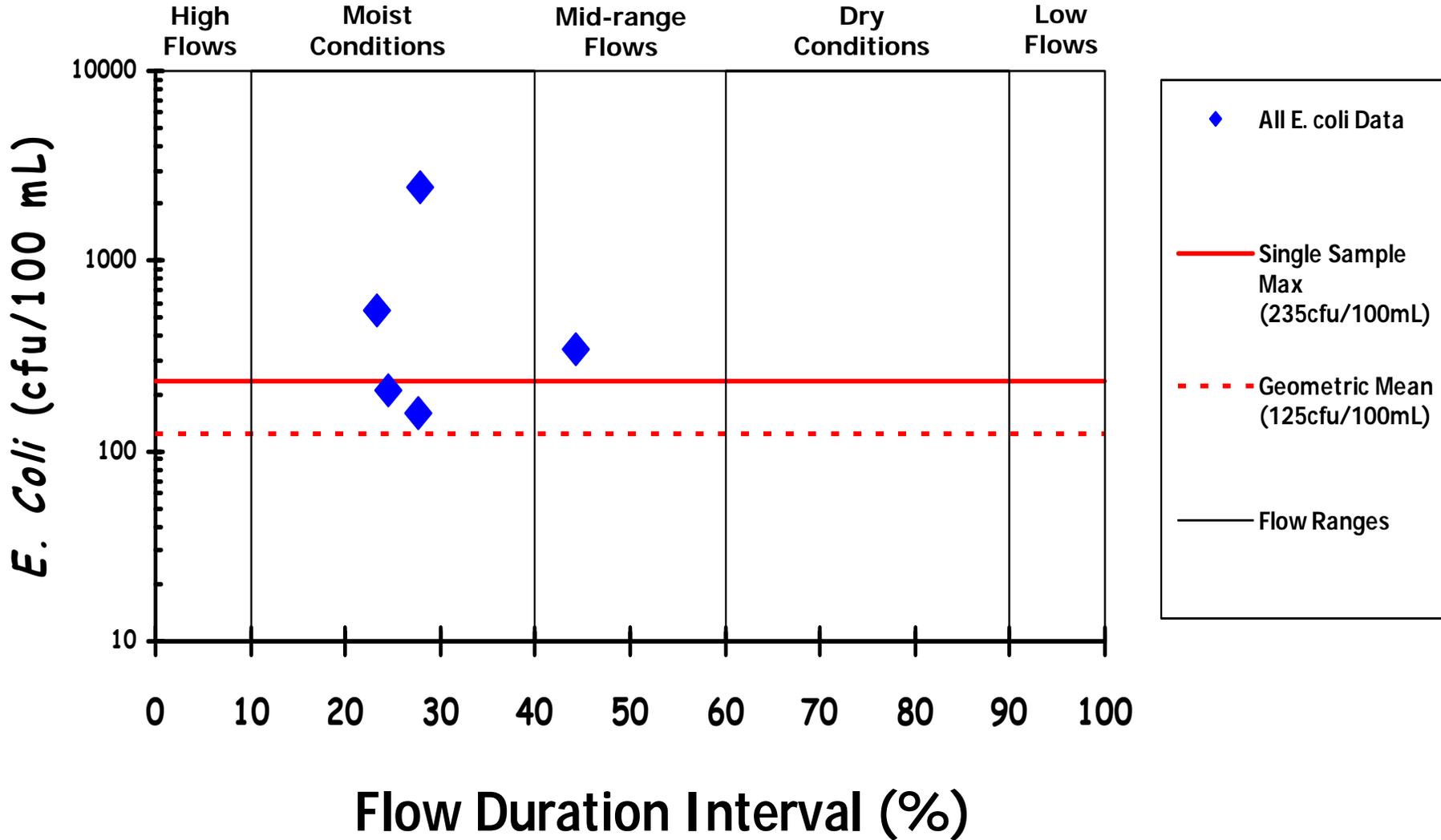
IDEM Water Quality Data & USGS Gage 03363500 Stream Flow Data

Upstream Drainage Area is 184 square miles

Attachment B : 2 of 6

# Montgomery Creek at Knightstown, IN

## *E. coli* Water Quality Duration Curve - Site: WED010-0019



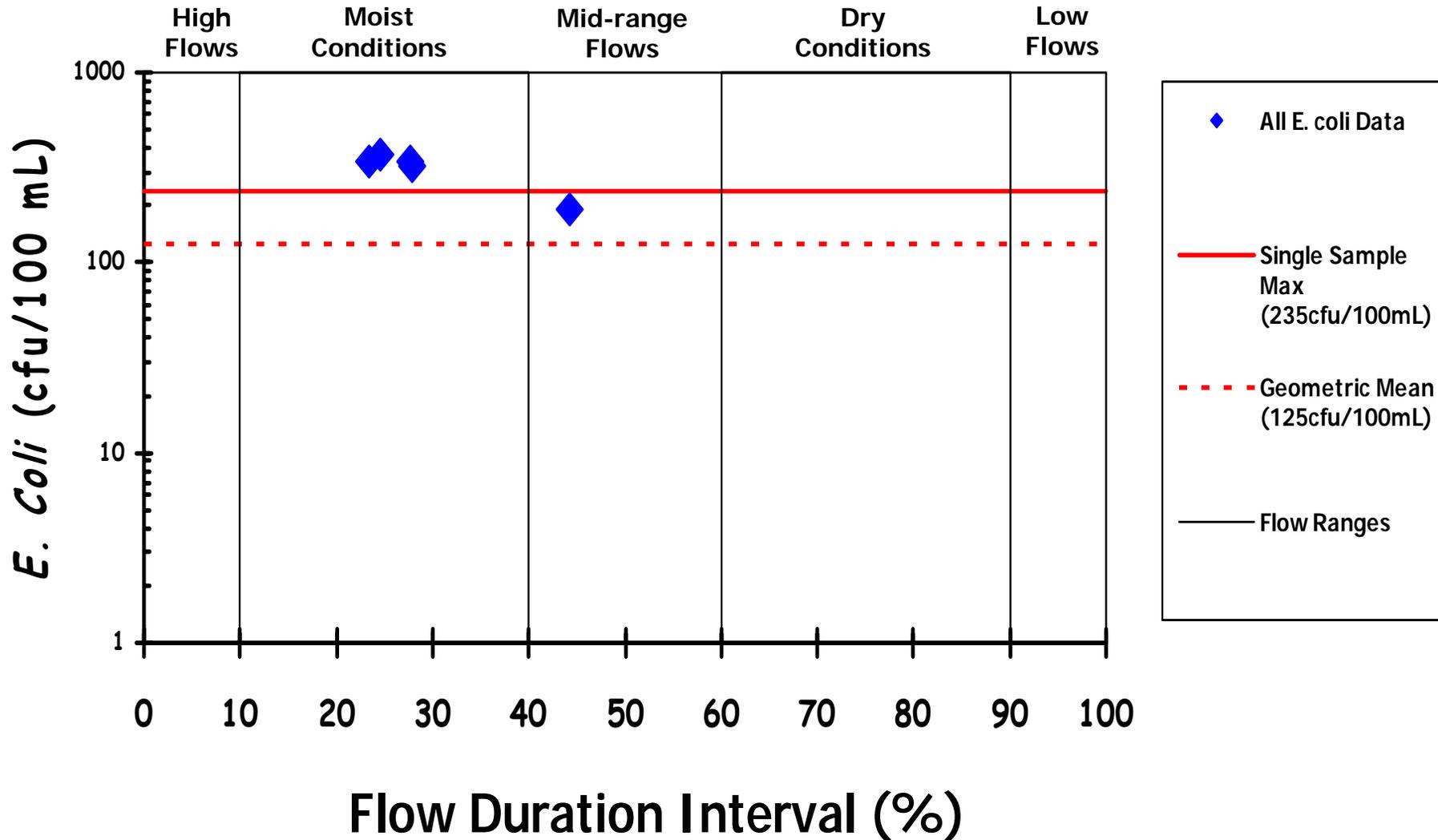
IDEM Water Quality Data & USGS Gage 03363500 Stream Flow Data

Upstream Drainage Area is 24 square miles

Attachment B : 3 of 6

# Buck Creek at S. Mill Rd near Spiceland, IN

## *E. coli* Water Quality Duration Curve - Site: WED010-0009



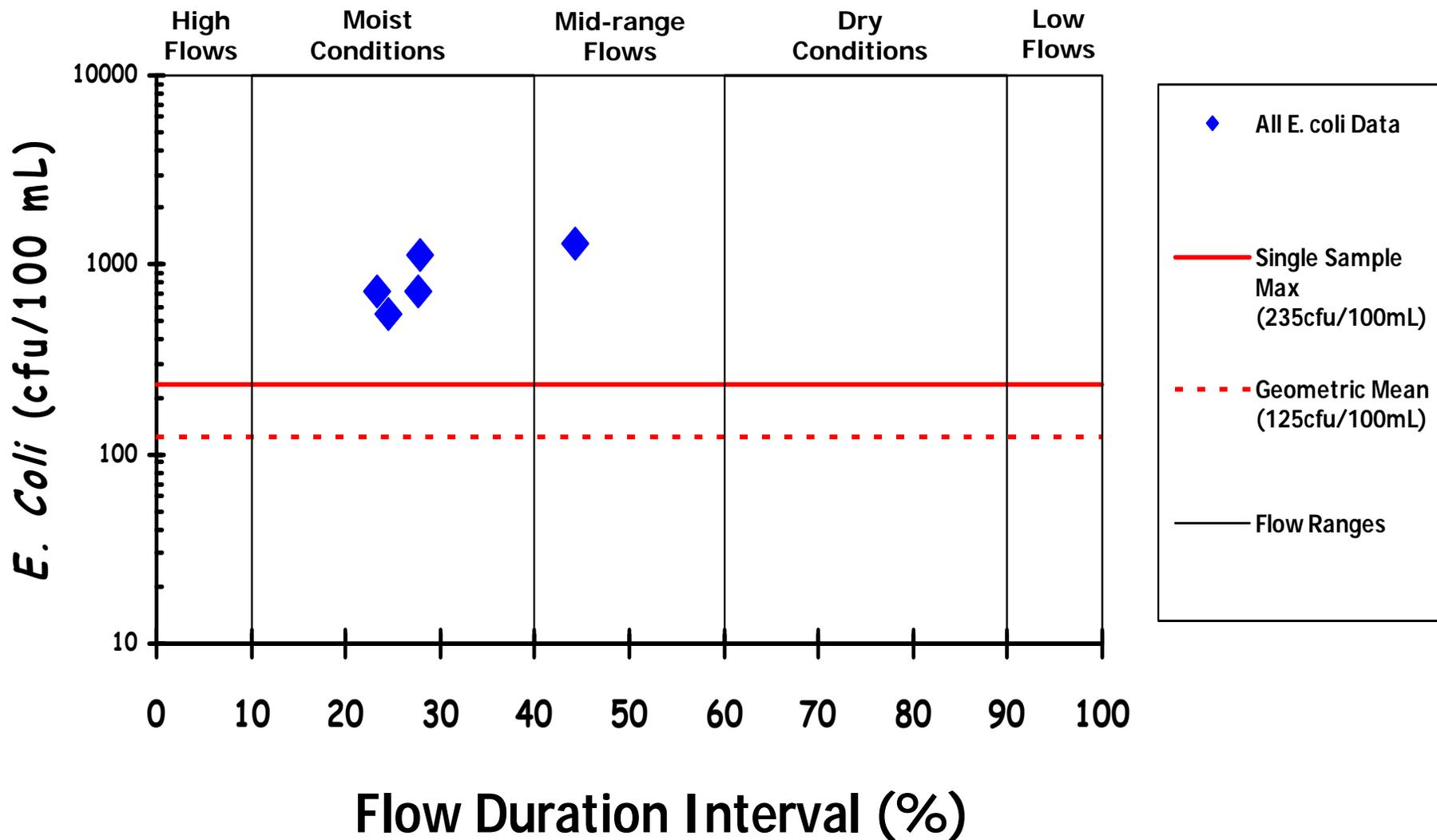
IDEM Water Quality Data & USGS Gage 03363500 Stream Flow Data

Upstream Drainage Area is 19 square miles

Attachment B : 4 of 6

# Duck Creek at Greensboro Rd near Spiceland, IN

## *E. coli* Water Quality Duration Curve - Site: WED010-0010



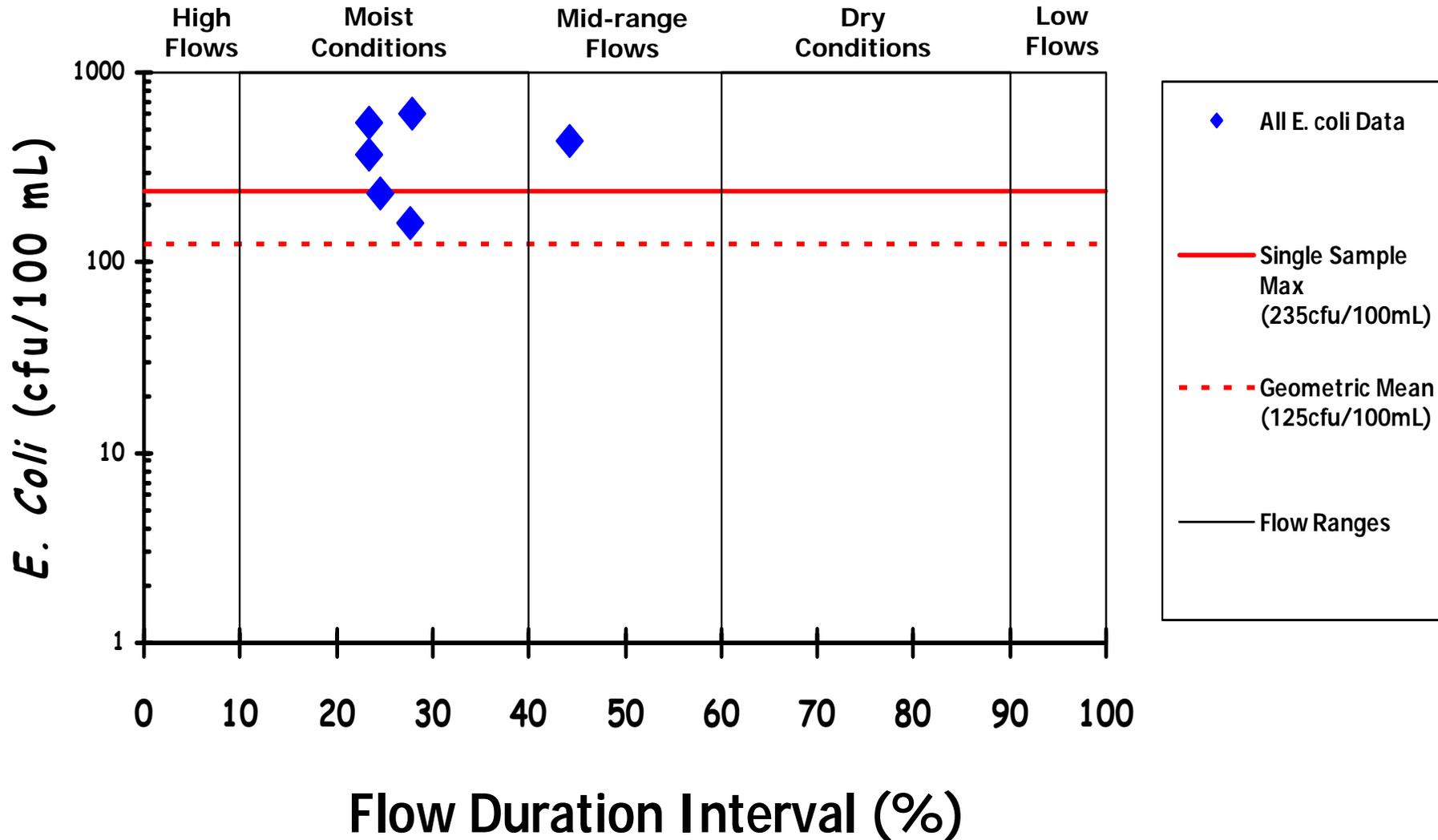
IDEM Water Quality Data & USGS Gage 03363500 Stream Flow Data

Upstream Drainage Area is 25 square miles

Attachment B : 5 of 6

# Little Blue River at SR 103 near New Castle, IN

## *E. coli* Water Quality Duration Curve - Site: WED010-0013



IDEM Water Quality Data & USGS Gage 03363500 Stream Flow Data

Upstream Drainage Area is 10 square miles

Attachment B : 6 of 6

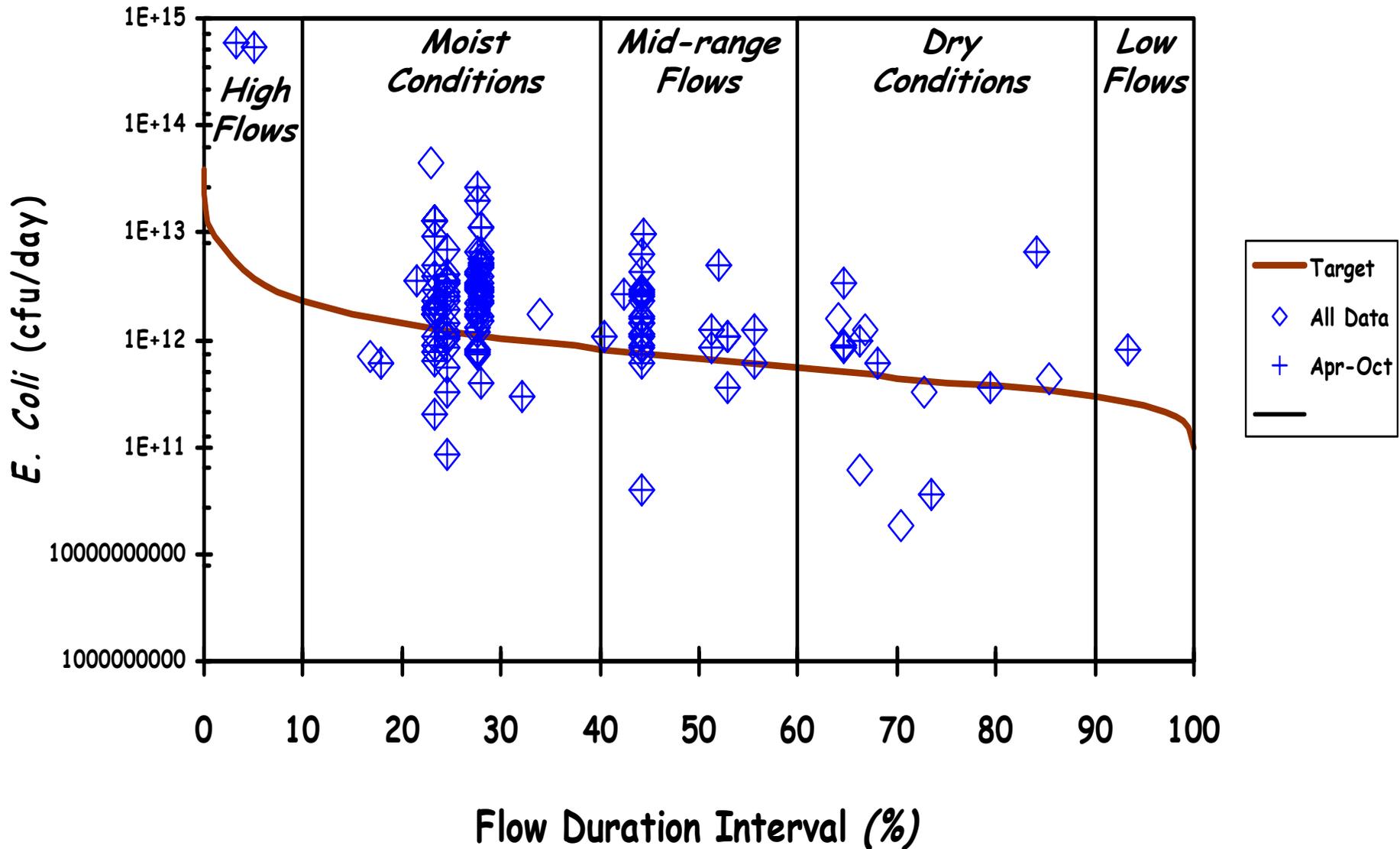
## **Attachment C**

### **Load Duration Curves for the Big Blue River Watershed TMDL**

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# Big Blue River at CR 800 E near Carthage, IN

## *E. coli* Load Duration Curve - Site: WED010-0035

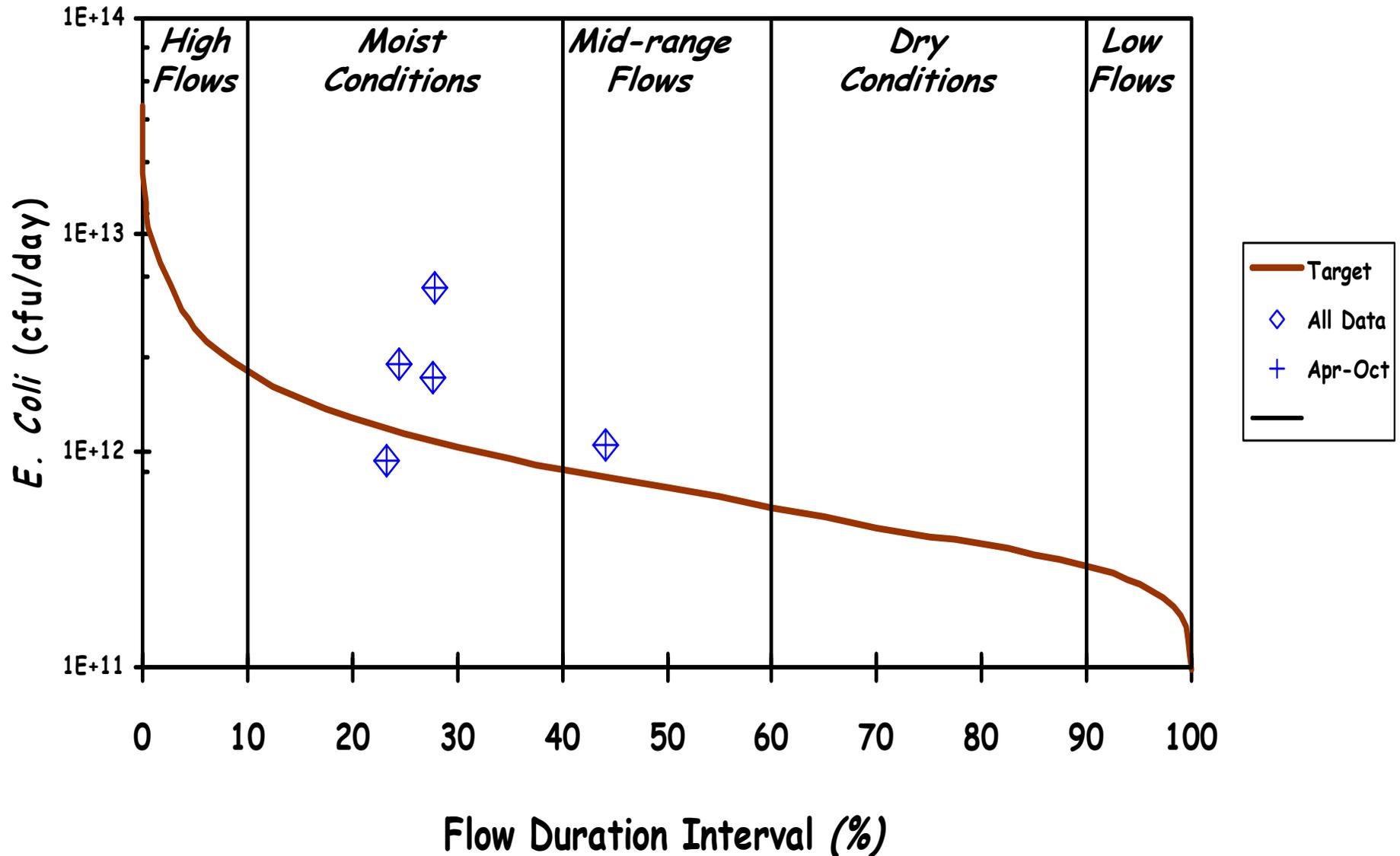


IDEM Water Quality Data & USGS Gage 03361000 Stream Flow Data

Upstream Drainage Area is 197 square miles

# Big Blue River at CR 800 N near Carthage, IN

## *E. coli* Load Duration Curve - Site: WED010-0034

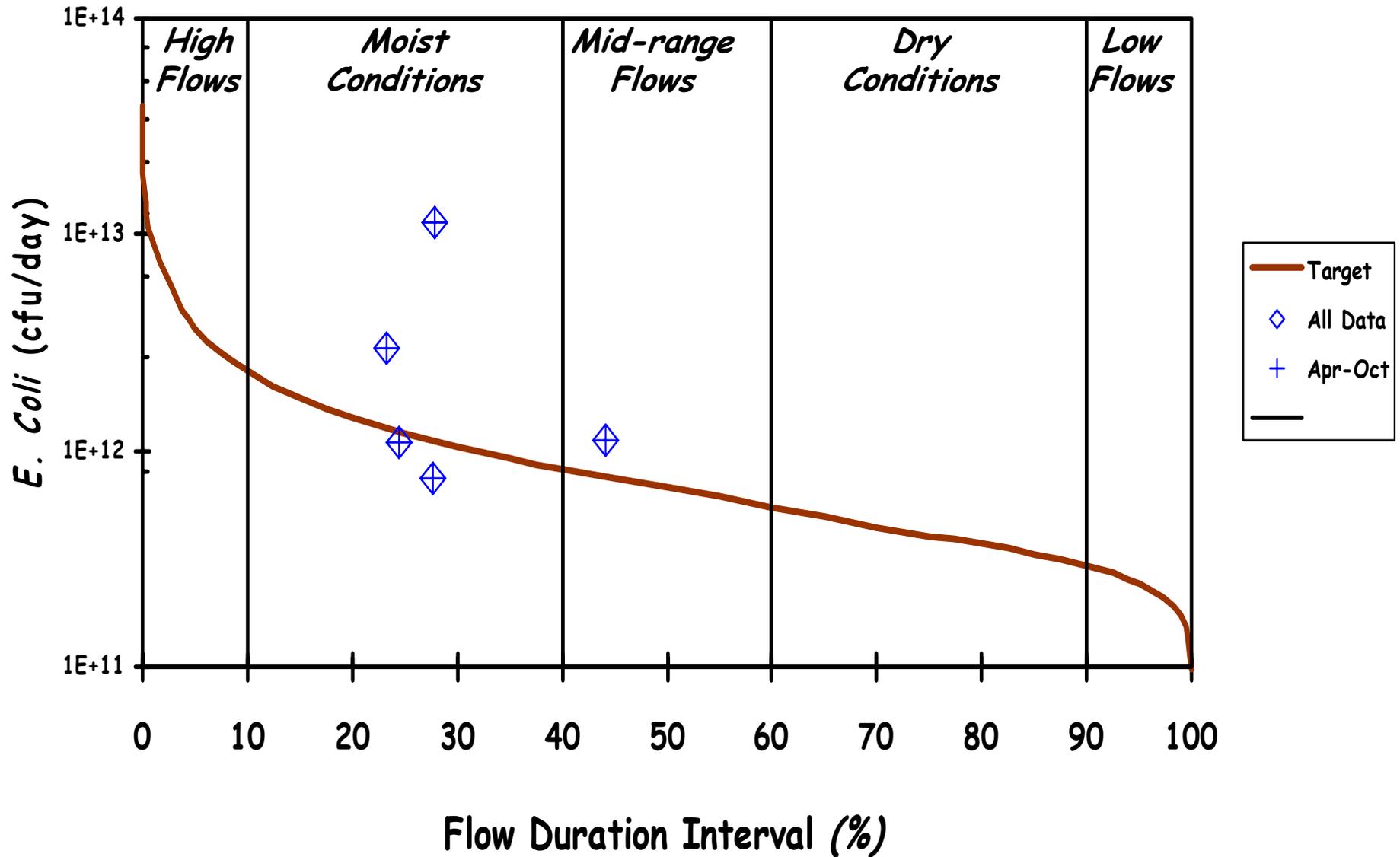


IDEM Water Quality Data & USGS Gage 03361000 Stream Flow Data

Upstream Drainage Area is 184 square miles

# Montgomery Creek at Knightstown, IN

## *E. coli* Load Duration Curve - Site: WED010-0019

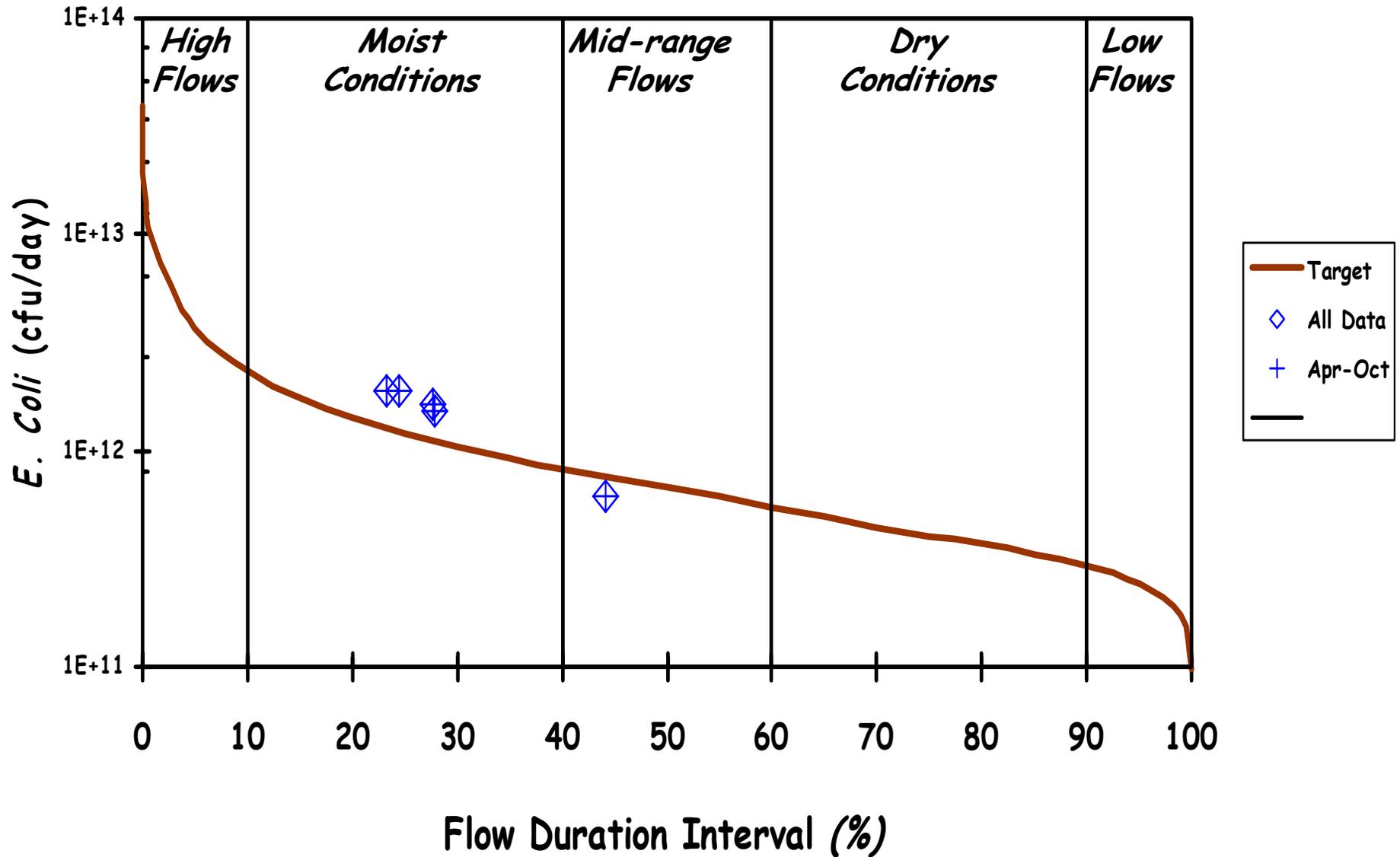


IDEM Water Quality Data & USGS Gage 03361000 Stream Flow Data

Upstream Drainage Area is 24 square miles

# Buck Creek at S. Mill Rd near Spiceland, IN

## *E. coli* Load Duration Curve - Site: WED010-0009

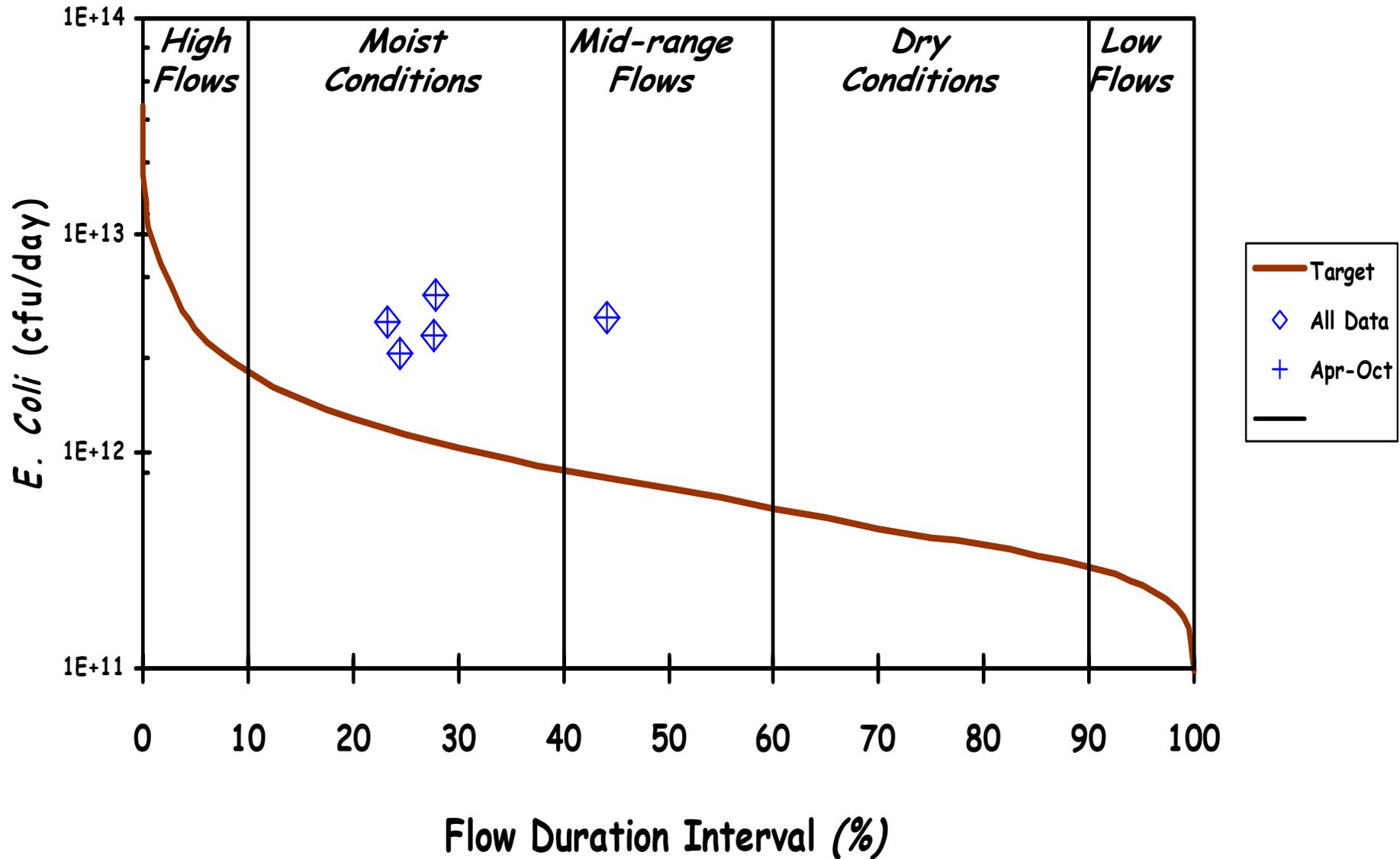


IDEM Water Quality Data & USGS Gage 03361000 Stream Flow Data

Upstream Drainage Area is 19 square miles

# Duck Creek at Greensboro Rd near Spiceland, IN

## *E. coli* Load Duration Curve - Site: WED010-0010

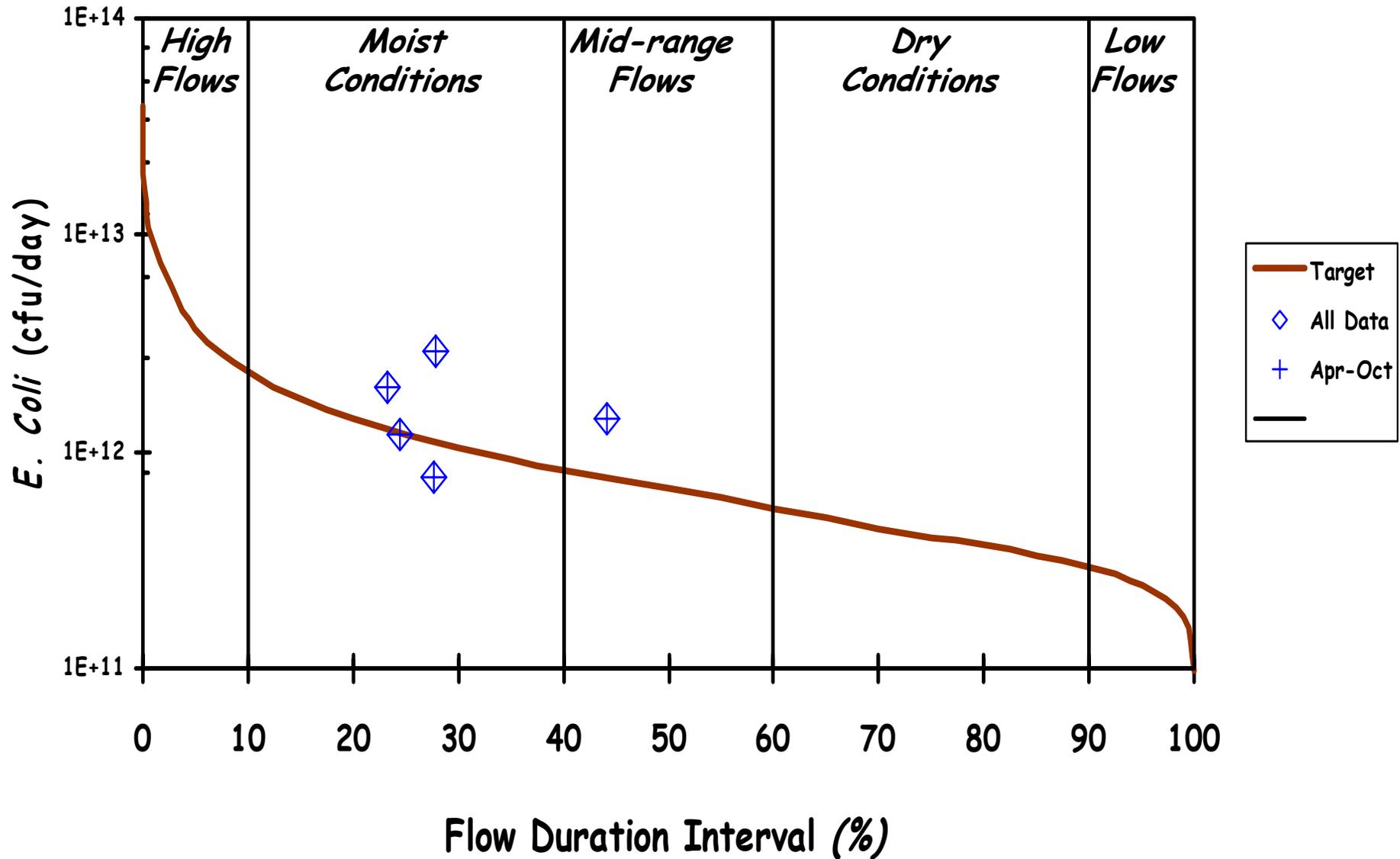


IDEM Water Quality Data & USGS Gage 03361000 Stream Flow Data

Upstream Drainage Area is 25 square miles

# Little Blue River at SR 103 near New Castle, IN

## *E. coli* Load Duration Curve - Site: WED010-0013



IDEM Water Quality Data & USGS Gage 03361000 Stream Flow Data

Upstream Drainage Area is 10 square miles